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Influence of the Technical Journal on National Advance

SPEAKING in Chicago recently at a conference of technical and business-paper editors, Dr. Hollis Godfrey, the well-known economist, said that:

"You have a definite function: To take the directing force of the printed page and organize the experience of industry; and, using editorials, circulation, and advertisements as the conductors of the facts and principles, to teach your group not facts alone but principles and facts. You never can teach arithmetic by a group of figures. You have to teach the rule, which is the principle. If you don't teach the rules as well as your figures, you are never going to advance wealth or advance your group. For facts, you have industries; for principles and processes, you have education. . . . It is your function continuously to increase material wealth by transmitting factual wealth. . . ."

Mining Journal claims a large share of credit as a factor in the accumulation of national wealth and the attainment of national well-being. As an independent publication, it rests on laurels that have been fairly earned as a result of long and intensive service in the interests of the mining industries. This service has been continuous over a long period. Established in 1866, a year in which 39 issues were published, it has since been the vehicle for an almost unbroken weekly dissemination of inspiration and information on technology, economics, and marketing. Its influence may be gaged mathematically by the fact that, by the end of 1927, no fewer than 3,211 issues had appeared. Its intrinsic merit can be evaluated from the fact that, starting as a national magazine, it has now an international reputation and circulation, with a subscription list in foreign countries amounting to one-third or more of the total. These circulation figures provide an index of mining progressiveness. Outside the United States, Canada heads the list, as might be expected; but Mexico has an almost equal number of readers. Central America, Cuba, and even Haiti are well represented. In South America, where United States investments have been large, Chile leads in number of subscribers, with Peru a close second. But *Mining Journal* also goes to the mining centers in Argentina, Bolivia, Brazil, Colombia, Ecuador, Venezuela, British and Dutch Guiana, and Uruguay. In Europe, Great Britain heads the list, but Russia—rapidly coming to the front as a mining country—is not far behind, being in fact, well ahead of Germany in point of circulation numbers.

The wide geographical distribution of *Mining Journal* in Europe is evidenced by the fact that it is read by engineers in Austria, Belgium, Bulgaria, Czechoslovakia, Denmark, Finland, France, Greece, Holland, Hungary, Italy, Jugo-Slavia, Estonia, Lithuania, Luxemburg, Norway, Poland, Portugal, Rumania, Spain, Serbia, Switzerland, Sweden, Turkey and Zagreb, the Serb-Croat-Slovene state. Even Cyprus is on the list; and Africa, of course, is well covered. In Asia, Japan absorbs a larger number of copies than any other country outside of the Americas, but *Mining Journal* also goes to India, China, Korea, and Persia. The Dutch East Indies has its readers, and Australian and New Zealand engineers are among the oldest subscribers. *Mining Journal* also circulates in New Caledonia, the Straits Settlements, Papua, and the Dominican Republic.

The success of the technical journal is due to the fact that it goes to the industries for information and inspiration that is broadcast back to the same industries as an assimilable and convenient record. This reflection of progress in amplified form has been the basic reason for the accumulation of wealth as a result of industrial expansion along technical lines. The part played by *Mining Journal* in national and world progress is one that should insure for the magazine the moral support of the industries it serves, and of the engineers directing those industries.

The Geologist—A Criticism

TO THE WORLD AT LARGE geology has taken a back seat, laments Dr. George H. Ashley in a recent number of *Science*. Fifty years ago, he says, the average man of culture had a better knowledge of the subject than the man of culture of today. Only a few of those who go to college are exposed to it, and many appear to have missed inoculation. Textbooks have been catalogs of facts; and, in the multitude of findings, the great truths have been lost sight of, even by geologists themselves, who, when their work leads them into something thrilling, content themselves by telling only their associates. As a result the public has lost interest in the subject.

True it is that an understanding of geology is restricted largely to the professions having need of it. Knowledge has multiplied so rapidly in fifty years that the Dr Faustus who tries to master or even to get a speaking acquaintance of everything, becomes merely a dabbler and a dilettante. Today the prevailing plan of education calls for thorough grounding in fundamentals, followed by specialization in some particular and narrow field of activity or research.

To what extent is geology a fundamental? Important geologic truths and facts that will facilitate a better

understanding of the history of man and his environment should be disseminated widely. But who cares, save the specialist, about the doctrine of isostasy, for instance? And what difference does it make to the average man, cultured or uncultured, if Mesozoic time began twenty-five million years ago or two hundred and fifty million years ago? Either period is long enough to stagger thought.

Our average man has enough to think about (if he will but set himself to thinking) without cluttering his mind with geological or other theories, which to him are so far afield. Let the specialist wrestle with his theories, and, when he has discovered a truth or something practical, pass it along in a form that is understandable and assimilable by the public. In the meantime, those interested in his work will be largely the members of his own profession. He who would grow in public esteem must serve the public well—and visibly.

Dr. Ashley proposes a remedy. He suggests that geology be made a science instead of, as he asserts, merely a collection of facts. "Physics and chemistry have a foundation of laws," he says. "But what laws can you find in our geologic textbooks?" These books as well as the teaching of the day need revision. Furthermore, he adds, geologists must get together on some of the more important facts; for instance, no two textbooks use the same major units for a time scale. He thinks, moreover, that reports intended for the public should be couched in simple, readable language.

Getting Down to Fundamentals

THE YEAR recently opened will go down into history in one respect at least as notable: Serious attention will for the first time be paid to the origin, nature, and causes of the common cold. A fund of nearly $200,000, provided by the Chemical Foundation, will make possible an investigation at Johns Hopkins University that should prove of benefit to a large proportion of humanity that, especially in the winter season, is afflicted with a distressing physical disability that often leads to serious trouble, but which, because of custom and prejudice, has hitherto been borne by the victim and contracted by his neighbor without protest against prevailing public opinion or the ineptitude of medical intervention.

The fund is to be known as the John J. Abel Fund for Research on the Common Cold, in honor of the professor of pharmacology at Johns Hopkins. In commenting on the gift, Dr. Abel said, *inter alia,* that "In the whole period of life from childhood to middle age, colds and their immediate consequences are the most important general causes of the impairment of efficiency, not to speak of the loss of all feeling of comfort and well-being."

The movement in favor of "daylight saving" was for a long time treated as a joke, because no one saw a personal financial gain in prospect if it were adopted. Any plant to understand or cure the common cold falls into the same category, and neglect has been obvious for the same reason, although one would have thought that the wealthy insurance companies might have discerned a field for useful and profitable investigation.

The ever-present but temporarily minor ills that flesh is heir to are on a par with those economic ills that are tacitly accepted as part and parcel of national business life. In themselves they may be merely irritating and exhausting, but in their developed stages and in ramified forms they usually represent the causes of industrial depression and business failure.

Competition and Industrial Progress in the Mining Industries

INDUSTRIAL COMPETITION is credited with having contributed in large measure to industrial and general success; but the argument that success in the past necessarily augurs success in the future usually ignores changing policies or increasing activities elsewhere. Success depends in part on the policy adopted by one's opponents. If the opposition policy remains unaltered, no change may be necessary. If, on the other hand, the tactics of one's opponents change, it is false philosophy to quote past success in prophecy of what will happen in the future. The United States is not alone in adherence to this philosophy; but Europe as a unit now finds that industrial co-operation is more attractive than industrial competition.

What is business competition but a type of industrial warfare? The irony of the present situation is that after preaching to Europe the blessings to be obtained by disarmament and co-operation and arbitration in international affairs, we continue, in molding our own industrial life, to encourage internal strife and mistrust, the while Europe takes our suggestions to heart and applies them to her advantage by the quiet co-ordination of allied business interests and the peaceful penetration of world markets. As between industrial competition and industrial co-operation, which of the two leads the easier to immoral and harmful practices? There is no need to ask. Experience has shown that, whatever the integrity of business as a whole, elements exist that, for immediate personal gain, are willing to betray the common good.

War involves waste, whether it be conflict between armies or between the various units of the same industry; and civil war or internal strife is the more destructive and the more demoralizing. In Europe it is being recognized that industrial war, or competition, is futile and costly; in the United States must one continue to subscribe to an article of faith that insinuates that any alternative is un-American and therefore reprehensible? Let us analyze this attitude: On the one hand, the leaders in an industry, unable to fix prices or allow a fixed fair price to be placed on their product for home consumption, are commended as law abiding and loyal because of their adherence to the letter and spirit of the Sherman Act; although restricted progress, even disaster, may result. On the other hand, the same leaders in the same industry are allowed, under the Webb-Pomerene Act, to "conspire" and fix prices in regard to the export of the same product and thereby to prevent the disintegrating effect of underhand and competitive bidding.

"Competition," we are told, "is the secret of American industrial success." A broad analysis is out of the question; but how can the axiom be applied to the mining industries? What does the word "competition" mean among the metal producers, for instance, apart from the legal right of one seller to shade price and thereby to disorganize the market for his own immediate personal gain? Drops of water will ultimately erode a hard stone. Similarly, the constant shading of price by those who

refuse or are not permitted to substitute co-operation for competition leads to depression and hardship.

Suppose that the domestic price of a metal were fixed at a fair figure, at a price permitting profitable operations to all concerned (within logical limits of course), and enabling the large producers to continue and to supplement an intensive campaign of research for better methods, social and technical, and the wider use of their product. Unfair competition only would be eliminated thereby. The higher and praiseworthy type of competition—the striving to improve recoveries and to lower costs, to encourage greater output per man by the payment of higher wages, to ameliorate unfavorable conditions and so to attract the best type of labor—this would be encouraged. It would be a friendly fight to gain preeminence, a fight for technical achievement such as is in progress in Germany today; not an underhand fight to take advantage of sales conditions.

Industrial competition is said to favor research, whereas the opposite is often the case. In one national industry that is permitted to co-ordinate its efforts and to charge a fair price for its "product," the annual expenditure for research—about $13,000,000—represents about 7 per cent of the total so expended by all the industries in and the federal government of the United States. Investigation without co-operation involves duplication and waste. Intensive competition invites secrecy—the foe to technical progress. Freed of the depressing threat of lowering prices, to a point that would barely cover cost of production, research would take on new life. The good of the industry would be the goal, as well as the profit to those sponsoring the work. Science must disregard international boundaries or artificial barriers to progress. Industrial research is but a feeble weapon if its scope is deliberately restricted by the mistrust engendered by internal competition.

What Constitutes Evidence of Invention

A PATENT DECISION based on fair and equitable reasoning was recently handed down by Judge Morton, of the Federal District Court for Massachusetts, a decision of wide interest to inventors and one which affirms that evidence of success is evidence of invention. The Court reviewed the history of the art in question prior to the introduction of the device invented by the applicant, and concluded that, although efforts had been made by others to overcome difficulties, no success had previously been achieved. The decision of the judge, reprinted in a recent issue of the *Scientific American,* included the following statement:

"All the elements which Jennings brought together were old, i.e., vacuum systems were old; a separating tank (or chamber) in such a system with an air pump and a water pump was old; rotary pumps for both air and water were old, and in condenser practice both had been mounted on a single shaft and run by the same motor; automatic control of the pumps in a vacuum system was old.

"All this being so I am still of the opinion that the steps that Jennings took involved invention. I am led to this conclusion in part by the immediate and extraordinary success it achieved in connection with the circumstances under which this success was obtained. The problem he solved had long been recognized, and the importance of it appreciated. On the solution of it the broad commercial success of vacuum steam heating with the great advantages it affords depended. But the problem remained unsolved until he accomplished what others had been unable to do. . . . It is well settled that this is strong evidence of invention."

In conclusion, the Court held that one who has achieved undisputed success where others have failed, in the evolution of something new and useful, is an inventor. The comments are commended to the attention of the officials of at least one South American patent office, where application for patent for an obvious invention may be and has been refused on the ground that the essentials, in themselves, are not new. By carrying this attitude to a logical or rather an illogical conclusion, excuse could be found for the rejection of almost all if not all patent applications.

In patent law, as much or more than in other branches of jurisprudence, it is unjust to the inventor to ignore evidence of actual achievement. Practice in a country whose patent office decisions, at the behest of interested parties, take advantage of a technicality to withhold protection from an inventor who has attained an undisputed technical success in a field where all others have failed is open to severe criticism. Sovereign rights may be claimed as sufficient to secure immunity from international interference; but the American engineer should be in a position to demand equitable treatment in patent matters abroad as well as at home.

Interpreting Science to the Engineer

FROM a thoughtful address delivered recently by Dr. C. R. Richards, of Lehigh University, at the Nashville meeting of the American Association for the Advancement of Science, one might evolve yet another definition of engineering: The application of fundamental science to the constructive and industrial arts. Doctor Richards maintains that no industry can feel secure until it is fully aware of the scientific basis of its activities; that additions to knowledge result from scientific research; that developments in industry follow the adaptation of such knowledge as a result of industrial research, and that on the combined outcome of scientific research and industrial research depends the progress of civilization and the improvement of the status of man.

It were illogical to dispute the fact that the great majority of engineers have neither the background nor the time to study each of the manifold advances in scientific thought. Doctor Richards suggests that the scientist and the engineer can be brought together to the advantage of both by widening the scope and defining the program of Section M of the Association. Representatives of the various branches of engineering should, at the meetings, summarize the latest applications of scientific knowledge to the industrial arts; and the pure scientists might well interpret and present the possible applications of the latest discoveries in their fields.

The technique of engineering is already adequately covered by the various engineering societies. What is needed is a more orderly and systematic contact of engineers with those versed in theoretical and scientific fundamentals. A new journal is suggested, designed to publish in understandable form the latest scientific data and discoveries, for the use of the engineer. All these ideas have merit and deserve consideration.

Status of
Leached Outcrops Investigation

PART I

By ROLAND BLANCHARD and P. F. BOSWELL
Duncan, Ariz.

TEN YEARS AGO the possibility of distinguishing a limonite outcrop left by the leaching of pyrite from one left by the leaching of chalcopyrite, chalcocite, sphalerite, or galena was given scant consideration. A limonite was a limonite; a gossan was a gossan; and in many cases the scout did not investigate further. Today not only is a limonite that has been derived from pyrite clearly distinguishable from one derived from the other sulphides named, but where the copper, lead, and zinc minerals are involved, the grade of the material prior to leaching can be judged in many instances as accurately as if the original sulphides were still visible in the outcrop.

The extent of the progress attained in this respect is well stated by Morse:[1]

"In the interpretation of leached outcrops much more has been accomplished than is generally recognized. Ten years ago the outcrops over the Miami orebody were a mystery and an act of God. The ore hunters shook their doubtful heads at the high-grade ore there and at the low-grade ore too. But we would now, after a brief study of the surface, outline the orebodies of various grades with complete assurance, and we would hit the grade within a few tenths of 1 per cent. That is surely making progress, even though Miami now seems to us the simplest of all crop-making things."

[1]H. W. Morse, private communication.

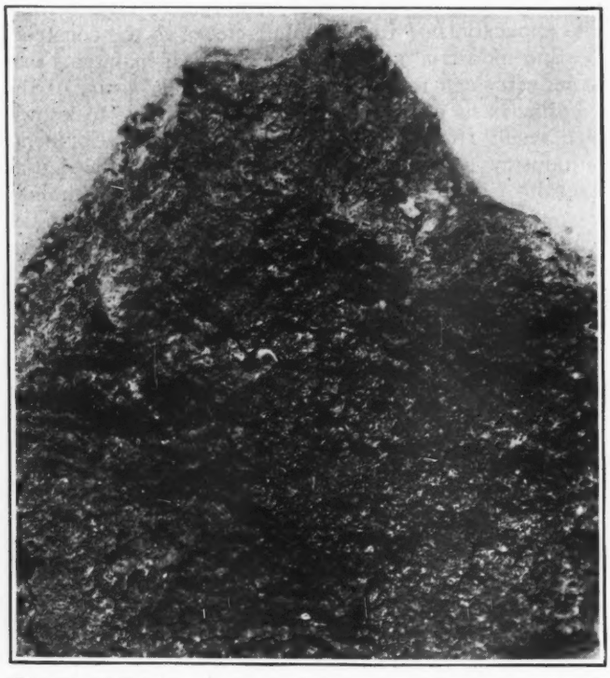


Fig. 1—Cellular limonite derived from massive pyrite along fracture in quartzite, traversed during oxidation by solutions from near-by limestone

Note the thick-walled cells with irregular, usually rounded cell openings. X1½. Near Daly-Judge tunnel, Park City, Utah.

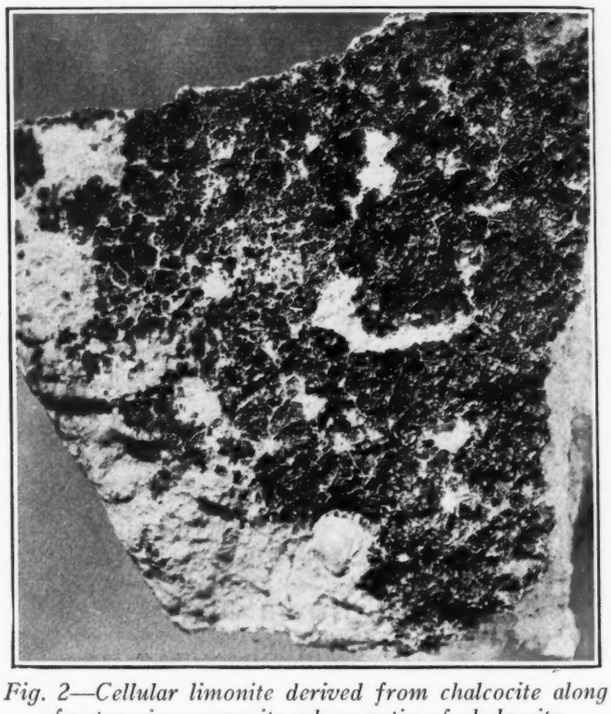


Fig. 2—Cellular limonite derived from chalcocite along fracture in monzonite where ratio of chalcocite to pyrite is approximately 2 : 1

Compare this clean-cut, thin-walled, cellular structure with the irregularly thick-walled limonite derived from pyrite, Figure 1. X1½. Outcrop over north portion Clay orebody, Morenci, Ariz.

That most leached outcrops can be today translated with more or less assurance into terms of the sulphides or other minerals from which they were derived is generally admitted. The purpose of this paper is to show how the judging of such outcrops is accomplished.

To the best of our knowledge Clyde Wardlow, a prospector of Plumas County, Calif., was the first to note differences distinctive enough in the limonite products left by the various sulphides to enable these limonites to be used as guides to particular sulphides. His original distinctions were based on the "dead look" of the pyrite product and the "live look" of the products derived from

Fig. 3—Coarse and fine cellular limonites derived from chalcopyrite in limestone

Note frequent persistence of the limonite veinlets in parallel lines past numerous cells, and especially the discordant, broken cell structure between the parallel veinlets. This is one characteristic of limonites derived from chalcopyrite. Note especially the absence of fluffy limonite, although oxidation occurred in a limestone gangue. The smaller cells carry pulverulent, slightly coalesced limonite particles; the larger cells are mostly empty, presumably due to the presence of admixed pyrite in the primary ore. X3. Las Palomas prospect, Jalisco, Mexico.

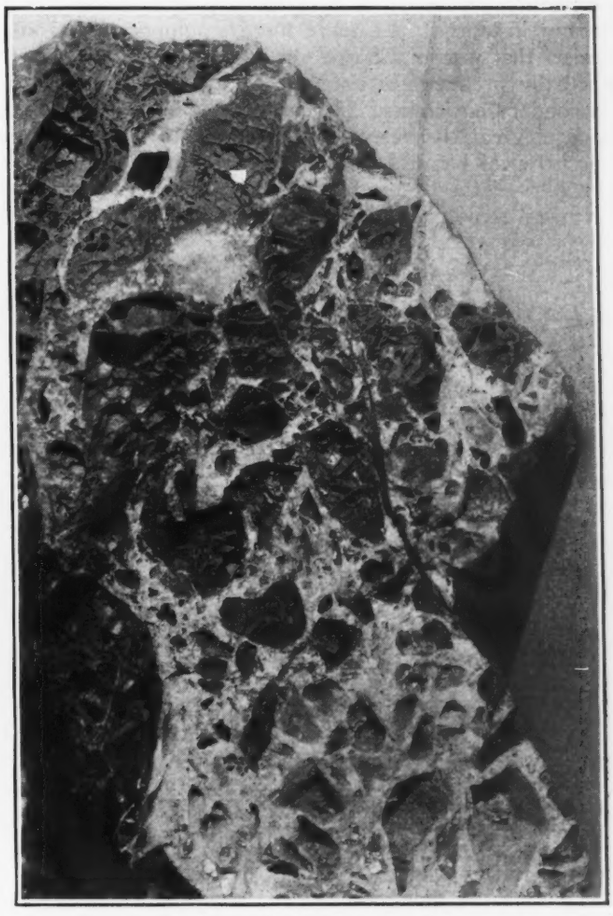


Fig. 4—Coarse cellular limonite derived from chalcopyrite in a quartz gangue

Note here, as in Fig. 3, the limonite veinlets in parallel lines past numerous cells, with broken cell structure between veinlets. These cells carry none of the pulverulent, slightly coalesced limonite particles. A higher pyrite content than in the specimen shown in Fig. 3 is therefore indicated for the chalcopyrite of this specimen. Note especially, at bottom, cavities in quartz gangue wholly free from limonite. From these pyrite has been leached, leaving no limonite. Pyrite, not wholly leached, is visible in the bottom cavities. X1¼. Los Aliados prospect, Sonora, Mexico.

certain copper sulphides, rather than upon characteristic differences that cannot be specifically defined. But so accurate did his judgment prove in interpreting certain of the leached outcrops of Plumas County that investigation on a much broader scale seemed warranted. This investigation was prosecuted under the direction of Augustus Locke, with the early field work directed by Charles Henry White.

Throughout the early stages of the investigation particular types of limonite were accepted as denoting pyrite, chalcocite, or other sulphide only when those types were seen to be actually grading into the sulphide in the particular piece of rock; it was not enough that the specimen of leached cropping occurred above known pyrite or known chalcocite. Even today, with the characteristic types of limonite from the different sulphides clearly established and proved as dependable guides over a wide range of geographic and climatic conditions, that method is adhered to in all cases where complete leaching of the outcrop, or of accessible exposures underground, has not occurred.

Before the leached-outcrops investigation had progressed far, it was noted that a pyrite or a bornite oxidizing in Plumas County did not necessarily yield the same type of limonite as it did when oxidizing in the moist climate of British Columbia or in the desert regions of Arizona and Mexico.[2] Even in the same district, when the sulphide in question oxidized in a quartz gangue, a different limonite product often resulted than when it oxidized in a feldspar or in a limestone gangue.

It thus became evident that while the gathering of field facts relating to the different limonite types was fundamental and a necessary preliminary to classifying the respective limonite products, there was needed, in addition, a thorough grasp of the chemistry and physics of the processes involved in the oxidation of the respective sulphides. In other words, information as to the amount of sulphur, iron, water, and oxygen available for and entering into the limonite-making reactions was required. Although the geologic literature was full of chemical "reactions" supposed to take place during the

[2]The term "limonite" is used in this paper in its commonly accepted sense—namely, the fine-grained, yellowish, brownish, or reddish deposits from decomposing iron-yielding minerals. It is recognized that the use of the term in this sense is not scientifically correct. See E. Posnjak and H. E. Merwin, "The Hydrated Ferric Oxides," *American Journal of Science*, Vol. 47, p. 311, 1919.

oxidation of the various sulphides, it was found that in many instances these were mere assumptions and surmises that were not borne out by the oxidation products actually produced in nature. And, just as the idea of secondary enrichment 25 years ago enabled us safely to forget great sheaves of field facts about dozens of ore occurrences because we could connect up the facts into an idea of the "processes" of secondary enrichment, so it was recognized that a correct knowledge of the

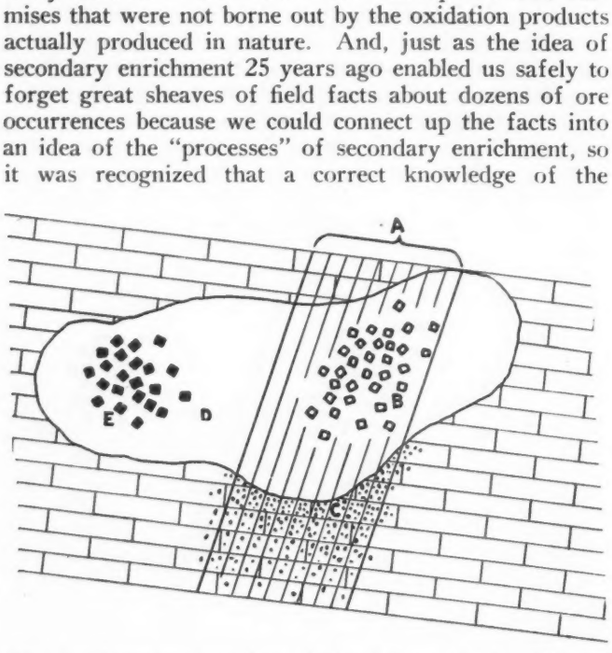


Fig. 5—Showing how iron derived from the leaching of pyrite in the Bisbee silica-breccias is precipitated as limonite at the limestone contacts

A, solution channel. *B*, area of leached pyrite; no limonite present. *C*, heavy precipitation of transported limonite at limestone contact. *D*, silica-breccia (quartz) mass in limestone. *E*, area of unoxidized pyrite.

"processes" of limonite formation would simplify the interpretation of leached outcrops under their many varying conditions, and in fact would be essential before the leached outcrops data could become intelligible and universally applicable.

Three factors essential to the correct interpretation of leached outcrops are: (1) A knowledge of what is in the rock or in the area of leached outcrop under consideration; (2) a knowledge of ore occurrences in all their variations; (3) a knowledge of the chemistry and physics of the processes which made that particular piece of rock or that particular leached outcrop what it is today. The second of these requirements probably will never be attained, but it may be approached through a sufficiently broad field experience.

Because the prospector frequently possesses only the first, and the scout often possesses only the first or the second, of these factors, errors are often made in recommending exploration in new areas; on the other hand, as will be shown later, areas of real promise are sometimes overlooked. And because the academic geologist is too often deficient in the first and second of these factors, or, in other words, in field experience, he commits equal or even greater errors. An accurate balance of all three factors is needed. Superficial knowledge of any of the three destroys the balance and usually invalidates the conclusions.

Sulphides whose limonites have been found to possess distinguishing characteristics that may be used in interpreting leached outcrops are chalcocite, sphalerite, chalcopyrite, pyrite, bornite, and galena. This list is given in the order of accuracy with which limonites derived from the respective sulphides may be distinguished. Stated another way: Limonites derived from chalcocite and sphalerite rarely cause confusion; but those derived from galena, though possessing certain definitely distinguishing characteristics, are more difficult to interpret because such characteristics are more often modified or obliterated by complicated processes before oxidation is completed.

Six sulphides by no means represent the full list of limonite-yielding minerals—sulphide and non-sulphide—whose oxidation products have been investigated in connection with this work. The full list comprises more than 25 minerals. The six named here represent merely those whose oxidation products have been checked over so wide a range of territory and under such varied climatic conditions that doubt no longer exists as to their use as dependable guides in interpreting leached outcrops. And, incidentally, the six are the ones most commonly found in sulphide deposits that are mined for their metal content.

Each of these six sulphides yields from three to seven characteristic limonite types that have been found to extend generally over western North America. In addition, they yield numerous "local" limonite types, peculiar to a single district. These are not considered here.

The particular type of limonite produced in any given case depends not alone upon the elements composing that sulphide, but usually upon a variety of outside factors, chief among which are the nature of the gangue and the nature of the associated sulphides. This explains why any given sulphide may produce more than one characteristic limonite type. It likewise explains why a knowledge of the physical-chemistry involved in the oxidation of the different sulphides, and in the reactions of the oxidation solutions with the various types of gangue, is essential if a leached outcrop is to be intelligently interpreted.

Despite these seeming complications, each type of limonite that has been differentiated in the work thus far is so distinct in physical characteristics that no one skilled in the interpretation is likely to confuse one type with another. To such a person the various limonite products left by chalcocite, sphalerite, or galena, for example, are not much more difficult to distinguish from one another than would be the respective copper, zinc, or lead carbonate or sulphate minerals. In this paper space does not permit description of the various limonite types derived from the oxidation of the six sulphides named. For descriptions of these the reader is referred to previously published papers.[3] Here are discussed only in a brief way some of the processes involved in the formation of those limonites. Figs. 1 to 4 inclusive illustrate typical limonites.

Need of Iron in Limonite Formation

Before limonite can form in any case where the oxidation of a sulphide or other mineral is concerned, iron salts must be present in the solutions, and the iron must be precipitated from those solutions. It follows that sulphides which do not carry iron—such as chalcocite, covellite, sphalerite, or galena—cannot leave limonite upon oxidation unless iron is supplied from some external source. That source may be associated pyrite. It may be iron imported during oxidation from some source

[3]H. W. Morse and Augustus Locke: "Recent Progress With Leached Ore Capping." *Economic Geology*, Vol. 19, No. 3, April-May, 1924. Roland Blanchard and P. F. Boswell: "Notes on the Oxidation Products Derived From Chalcopyrite," *Economic Geology*, Vol. 20, No. 7, November, 1925. Augustus Locke: "Leached Outcrops as Guides to Copper Ore," published by Williams & Wilkins, Baltimore, Md., 1926. P. F. Boswell and Roland Blanchard: "Oxidation Products Derived From Sphalerite and Galena." ***Economic Geology*, Vol. 22, No. 5, August, 1927.** Charles Henry White: "Prospecting for Disseminated Copper by a Study of Leached Croppings." *Engineering and Mining Journal*, March 22, 1924, pp. 483-488.

entirely outside the orebody and brought in by surface-water solutions. It may be, as sometimes happens in the case of sphalerite, isomorphous with the sulphide itself. But from whatever source derived, the iron must be supplied during the oxidation of those sulphides, or no limonite results. Most commonly the iron, in such cases, is imported in solution by surface waters as ferric sulphate. And most commonly, though not necessarily, oxidizing pyrite, either within or outside the orebody, is the source of the ferric sulphate.

Adequate Sulphur Required for Oxidation

Just as iron is needed before limonite can form from the oxidation of sulphides, so sufficient sulphur is needed before the sulphides themselves will oxidize. If insufficient sulphur is present, as in the case of chalcocite,[4] the sulphide cannot oxidize completely unless acid solutions reach it from some outside source. The higher the sulphur ratio to bases, the more readily will the sulphide oxidize, other things being equal. Thus, pyrite, which carries a high proportion of sulphur to iron, oxidizes readily to ferric sulphate. Furthermore, the large sulphur ratio produces so high a degree of acidity that the iron is held in solution and is carried away unless precipitated by a neutralizer or by some other precipitating agent. It therefore usually happens that where pyrite oxidizes in a gangue free from neutralizer, such as a quartz gangue, no limonite is left, even though a large amount of iron was in solution. (See Fig. 4.) This is a common condition at Bisbee, where in the pyritic portions of the silica-breccias of the limestone, oxidation in many places has completely removed evidences of former mineralization except for the empty pyrite pits remaining; but at the outer edges of the silica-breccias, where the acid solutions from the oxidation of the pyrite came in contact with the strong calcium carbonate, neutralizer of the limestone, "fringes" of transported limonite, 15 to 20 ft. wide, adjoin the silica-breccia masses. And the "fringes" exist only in the channels followed by these solutions.

Chalcopyrite contains enough sulphur to dissolve the sulphide and to carry off in solution all the copper and part of the iron, but not all the iron. Some of the iron is precipitated in place as limonite. Associated pyrite or imported iron therefore is not needed for chalcopyrite, upon oxidizing, to leave limonite.

In sphalerite and galena, no iron is present in the pure sulphide. Just enough sulphur is present to dissolve the sulphide and carry the zinc or lead away in solution. No limonite therefore is left unless iron was supplied during oxidation from an external source. Usually such iron is supplied. In many cases where no pyrite was visible in the sphalerite or galena in the hand specimen, it was found when the sulphides were examined under the microscope.

In chalcocite, no iron is present; and, as previously stated, not enough sulphur is present to dissolve the sulphide completely. This explains why essentially pure chalcocite, not traversed by surface waters, often is unoxidized when chalcopyrite and pyrite near by are thoroughly leached to depths of several hundred feet. The common solvent in nature for chalcocite is ferric sulphate. As already stated, pyrite is the most common source of ferric sulphate, and where pyrite is associated with the chalcocite—as is almost universally the condition in disseminated copper deposits—all the needed elements are present for leaching of the chalcocite, for transportation of the dissolved copper to greater depths for secondary enrichment, and for the formation of limonite in the leached cropping. In a deposit where the sulphide is 100 per cent chalcocite, and over which there flow no surface solutions carrying iron salts, leaching, secondary enrichment, or the formation of limonite from the chalcocite would not take place.[4]

Recapitulation

1. For sulphides to dissolve by oxidation sufficient sulphur must be present to put the sulphides into solution. If the sulphides themselves do not carry sufficient sulphur, as is the case with chalcocite, complete oxidation cannot take place unless the deficiency is supplied from an external source. This source usually is ferric sulphate, and is most commonly derived from oxidizing pyrite.

2. Even though oxidation of the sulphide occurs, no limonite will form unless iron salts are present in solution during the oxidation and are precipitated from such solution. Thus, though sphalerite and galena in the pure state carry sufficient sulphur for complete oxidation, they leave limonite only when iron salts from some external source, usually from admixed or associated pyrite, are available during the oxidation.

Fig. 6—Cellular limonite derived from finely disseminated chalcocite in monzonite

The disseminated cavities here are small, but are almost completely filled with the limonite, showing thorough replacement of the pyrite by chalcocite. This is "A" cropping. Ore beneath it will assay more than 2 per cent copper, as chalcocite. X2. Outcrop over high-grade portion of Racket orebody. Tyrone, N. M. This is the exceptional type of leached cropping at Tyrone. It is the normal type at Miami, except that the cavities in Miami cropping usually are larger.

3. Where iron salts are present and the acidity of the solution is high, as in the case of oxidizing pyrite, and where no neutralizer or other precipitant effects precipitation of the iron, the iron may be carried almost any distance, from a fraction of an inch to many miles, before

[4]It seems probable that chalcocite may oxidize to a limited extent without an external sulphur supply, so that half its copper is soluble as $CuSO_4$. Though this is possible, the field evidence shows that such oxidation is rarely important. For all practical purposes in interpreting leached outcrops, it may be disregarded.

precipitation takes place as limonite. Usually the distance is not more than a fraction of an inch, because in all gangues except quartz sufficient neutralizer usually is present to effect precipitation.

Since pyrite produces high acidity in the solutions, and since high acidity favors exportation of the iron from the point where the sulphide is oxidizing, it follows that

Fig. 7—Fluffy limonite filling cavities from which pyrite has been leached. Monzonite gangue

Surface waters carrying $CaCO_3$ in solution flowed over this area during oxidation of the pyrite and precipitated the limonite within the cavities. No copper is denoted beneath this cropping although the cavities are filled with limonite, as was the case in the specimen shown in Figure 6. X2. Bagdad, Ariz.

the higher the ratio of pyrite to the other sulphide in any given case, the less likely is limonite to be precipitated at the point of oxidation.

The Pyrite Ratios

The foregoing points are the vital considerations in the judging of leached outcrops: for the amount of admixed or associated pyrite in the case of the other five sulphides named determines largely the type of limonite produced, its distribution with respect to the oxidizing sulphide, and, through these two factors, the accuracy with which the leached outcrop may be interpreted.

As an example, the leached outcrops over the chalcocite orebodies at Miami show a characteristic chalcocite limonite similar to that of Fig. 2 and Fig. 6, with nearly all the limonite precipitated within the cavities that were vacated by the sulphides. Here the ratio of chalcocite to pyrite in the ore is approximately 2:1, and this same type of limonite, precipitated almost entirely within the cavities formerly occupied by the sulphides, prevails in most monzonite gangues of leached, disseminated chalcocite deposits where the ratio of chalcocite to pyrite was 2:1. On the other hand, the leached outcrops over the chalcocite orebodies at Tyrone show this type of limonite with slightly less angular and slightly more rounded cellular structure; but except in the richest portions of the ore areas most of the limonite is precipitated immediately outside the cavities formerly occupied by the sulphides. At Tyrone the ratio of chalcocite to pyrite in the ore is approximately 1:2, and this same type of limonite and distribution with respect to the cavities prevails in most monzonite gangues of leached, disseminated chalcocite deposits where the ratio of chalcocite to pyrite was 1:2. But even in these cases a border of the chalcocite-derived limonite "fringes" the cavity, so that the presence of former chalcocite is denoted.

Explanation for these different patterns of limonite distribution with respect to the cavities is that where the ratio is 2 chalcocite : 1 pyrite, as at Miami, just enough sulphur is present for all the copper and all the iron to go into solution, for all the copper to be exported, but for none of the iron to be exported. The iron consequently remains in the cavities as limonite.

Where the ratio is 1 chalcocite : 2 pyrite, as is the case for most of the Tyrone area, enough sulphur is present for all the copper and all the iron to go into solution; but an excess of sulphur exists which produces in the solutions an acidity so high that not only is all the copper exported, but most of the iron likewise is exported. The iron is carried outward from the cavity until the solutions reach the monzonite gangue, where the feldspar neutralizer precipitates the iron as limonite near the edge of the cavities.

Where the pyrite content is greater than 1 chalcocite : 2 pyrite, the limonites formed are even more rounded in cellular pattern—approaching more closely the pyrite types of limonite represented in Fig. 1—and the iron may be carried still farther outward from the cavities before being precipitated as limonite. The distance carried depends largely upon the amount of neutralizer in the gangue. In a quartz gangue, where no neutralizer is present, it might be carried to the edge of the quartz mass before being precipitated as limonite. In limestone, where the calcium carbonate constitutes a very rapid neutralizer, precipitation probably will occur immediately at the edge of the cavity. This matter is discussed in greater detail in the second part of this article under "Influence of Neutralizer."

It is thus evident that in leached outcrops over disseminated chalcocite deposits, the type of limonite produced and its distribution with respect to the cavities depend chiefly upon the sulphur-iron ratio of the sulphides that have been leached and upon the amount and character of neutralizer in the gangue. Other factors play a part, among which are hydrolysis, adsorption, and dilution of the solutions, but these are of subordinate importance and are not discussed here.

It is equally evident that by knowing the neutralizing power of the gangue, by recognizing the particular type or types of limonite precipitated, and by observing the amount and distribution of each with respect to the leached cavity—all this can be ascertained by careful examination of the surface—it is a simple matter to determine what sulphides have been leached. Thereafter, estimation of the grade of the ore that has been leached depends upon the skill of the individual, but is no more difficult than would be estimating the grade if leaching had not occurred and the chalcocite and pyrite were visible.

An ideal example is one like Miami, where the ratio is 2 chalcocite : 1 pyrite, so that (1) all the limonite left is the most outstandingly characteristic and most easily recognized chalcocite type; (2) the limonite remains almost entirely within the leached cavities; and (3) the amount of neutralizer in the gangue is just sufficient to

precipitate at the edge of the cavity whatever iron may migrate from the cavity where locally an excess of pyrite occurs, and still low enough not to precipitate the copper from solution as copper carbonate, sulphate, or silicate; so that all the copper may be carried to the secondary chalcocite zone below. This is what Morse refers to as "the simplest of all cropping-making things," because nothing exists to cause complications.

Most leached outcrops are more difficult than Miami to interpret, but they yield to persistent attack. The chief difference is that more factors are involved in the formation of their limonites, and consequently more skill is required in the interpretation.

Deposits such as those at Bagdad, Silverbell, and Chino, where the ore occurs lenticularly along fracture zones, may be judged from the leached surface croppings nearly as accurately as those at Miami and Tyrone, provided the areas examined are sufficiently large, so that the surface exposures present an average of the mineralization; and provided, further, that due weight be given to the greater amount of neutralizer in the gangue at these places, which precipitates a part of the leached copper as carbonate, silicate, sulphate, oxide, and native copper, and withholds from the chalcocite zone a corresponding amount.

In the massive type of deposit in which the ratio of pyrite to that of the chalcocite or other sulphide may be 10:1 or 20:1, greater difficulty is experienced in arriving at an accurate interpretation of the leached outcrop. The reason for this is that where a great excess of pyrite exists, the smeary crusts and other limonite types characteristic of pyrite (see Fig. 8) may obscure or obliterate the types characteristic of the other, less dominant sulphides; and the latter consequently may not be present in their true proportions in the leached outcrop. But it is worth noting that in the leached outcrops that formerly overlay the massive pyrite ore areas of Sacramento Hill, at Bisbee; the United Verde orebody, at Jerome; and the leached massive sulphide orebodies of Granby, at Anyox, the evidence in the croppings of former chalcocite and chalcopyrite was by no means obliterated, even though the ratio of pyrite to combined chalcocite and chalcopyrite was in places higher than 10:1. Although an accurate estimate of the grade of the copper ore leached from these outcrops would not have been possible, enough evidence of leached chalcocite or chalcopyrite, or both, was present to demand exploration on an extensive scale.

In the disseminated type of deposit, as contrasted with the massive type, classification is much more definite. In our field work the classification used is: A, ore; more than 2 per cent copper; B, doubtful; 1.25 to 2 per cent copper; C, low-grade; less than 1.25 per cent copper; D, waste; barren, or essentially barren, of copper.

Space does not permit describing the methods used in judging outcrops leached of chalcopyrite, bornite, sphalerite, or galena. These have been described in previous papers.[3] The methods for judging them vary somewhat in detail from the method here described for judging leached chalcocite deposits, but the same underlying principles apply; namely, (1) recognition of the particular limonite types; (2) determination of the neutralizing power of the gangue; (3) determination of the sulphur-iron ratios involved in the oxidation; (4) knowledge of that type of deposit in all its variations; (5) knowledge of the chemistry and physics of the processes which are needed to produce those particular limonite types and those particular habits of distribution of the limonite.

One point should be noted: When pyrite, chalcocite, chalcopyrite, or bornite go into solution, the limonite, under normal conditions, is precipitated directly from the reactions involved. When sphalerite or galena go into solution, the limonite usually is not precipitated directly from those reactions; it does not normally form until the secondary sulphates and carbonates have been produced and in turn gone into solution. The formation of limonites from the oxidation of sphalerite and galena is therefore a more complicated process than their formation from pyrite or from the copper sulphides. This greater complication tends somewhat to obscure the physical features by which the resulting limonite types may be recognized, especially in the case of galena. But although the distinguishing characteristics are somewhat obscured, we have never found an instance in the field in which they could not be distinguished if a careful search be made.

A recent paper describes in detail the various limonite types characteristic of the leached zinc and lead minerals, discusses the physical-chemical processes involved in their formation, and explains the methods used in interpreting leached outcrops containing them.[5] The main point to note here is that though it is possible for sphalerite and galena to leach without leaving limonite, they do usually leave it, and such outcrops therefore are subject to intelligent interpretation.

[5] P. F. Boswell and Roland Blanchard: "Oxidation Products Derived From Sphalerite and Galena." *Economic Geology*, Vol. 22, No. 5, August, 1927.

(To be continued)

Mining in Ethiopia Confined Chiefly to Mica Deposits

DEPOSITS of iron exist in several parts of Ethiopia (known as Abyssinia in recent years, up until 1923), but they have been used by the natives only for the manufacture of more or less primitive tools and weapons —spears, knives, and hatchets, according to J. Loder Park, U. S. vice-consul at Aden. Placer gold mining and washing is carried on by the natives in some of the eastern districts, where gold is found in several of the river beds. Exports average in value about $200,000 a year. It is reported that if the quartz deposits said to exist in the country were exploited, production would reach much larger proportions.

Since 1911 the concession for the exploitation of extensive deposits of potash salts in northeastern Ethiopia, near Eritrea, has been held by an Italian company, which has done some development work and exported some potash, chiefly to Italy.

Concessions are held by an American company for the exploitation of mica mines in four sections of the country: in Lake and Walloga in the west; in the country of the Ogaden near Somaliland; in the vicinity of Harar; and around Aussa, near French Somaliland. Mining has been begun in the section between Harar and Jijiga, where the mica is reported to be of excellent quality, and exportation was begun in 1923. The deposits are abundant, but the exploitation so far has been somewhat handicapped by difficulties of transportation, inasmuch as the mines are separated from the nearest railway point, Diredawa, by about 100 miles of very rough country. The possibility of an alternative export route, however, has been suggested, through British Somaliland to the port of Berbera, for which only 40 miles of new road would have to be constructed.

How and Why

SALVAGED

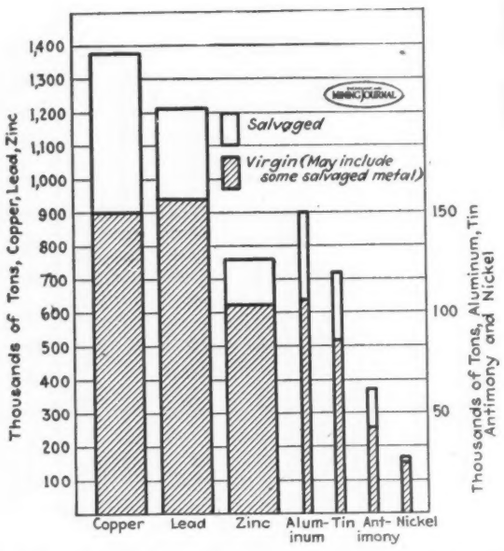


Fig. 1. Relation between salvaged "production" and virgin consumption of metals in 1926

RECENT investigation justifies the statement that a comparatively small minority of those engaged in the mining, smelting, and refining of non-ferrous metals fully appreciate the vital importance—and the rapidly growing importance—of the secondary or salvaged-metal industry upon the markets for primary or virgin metal. Possibly there is a tendency in some quarters to take an ostrich-like attitude and hide one's head in the sand, in hope that the "menace" will be avoided if the existence of it is ignored. That, of course, is only folly. Moreover, as I shall attempt to show, the salvaged-metal industry has certain salutary influences on the markets that compensate, to some extent, for the undeniable fact that prices for newly produced metals would be higher if industry swallowed virgin metal like an ocean from which nothing could be reclaimed. And, of course, from the point of view of society at large, the salvaging of "used" materials—and of metals, particularly, because of them the aggregate available supply is limited—is in accord with the sound principles of economic efficiency and conservation of resources. The following facts are significant:

1 The value of once-used non-ferrous metals, base and precious, salvaged and returned to industry or the arts in the United States in 1926 was about $315,000,000. See the table on page 287.

2 For every pound of new copper mined and shipped for domestic consumption, 0.53 lb. of salvaged copper was marketed. Corresponding figures for the other major metals are: lead, 0.30; zinc, 0.23; aluminum, 0.41; tin, 0.38; antimony, 0.44; and nickel, 0.12. These data for the year 1926 are shown graphically in the accompanying block chart, Fig. 1.

3 The last five years have witnessed a tremendous increase in the quantities of salvaged metal of various kinds that are being returned to industry for re-use. While the production of mines, generally speaking, has increased steadily, the current output of plants that supply metal from salvaged material has increased much more rapidly. These data are shown graphically in Figs. 2, 4, 6, 8, 10, 11, and 12.

4 At a recent meeting in New York of the National Association of Waste Material Dealers the following

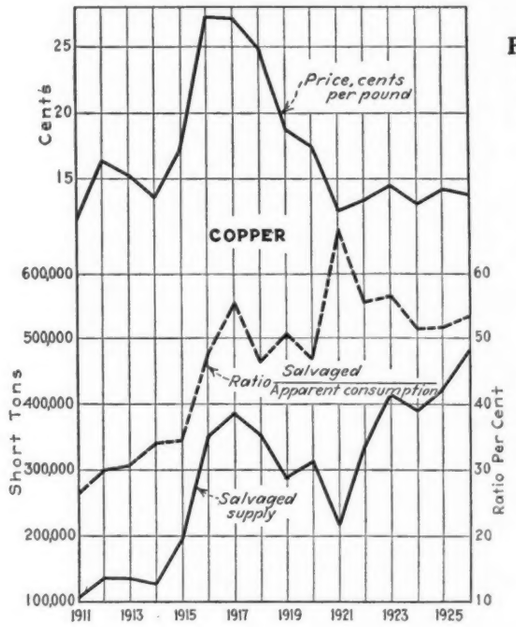


Fig. 2

well-known corporations among others were represented by responsible officials:

Aluminum Company of America
American Electrical Works
American Metal Company
Baltimore Copper, Smelting & Rolling Company
Boston & Albany Railroad
Bridgeport Brass Company
Central Alloy Steel Corporation
Chevrolet Motor Company
E. I. du Pont de Nemours & Company
Eastman Kodak Company
Erie Railroad Company
General Electric Company
General Chemical Company
Hudson Motor Car Company
Humble Oil Company
John A. Roebling's Sons Company
Lehigh Valley Railroad Company
New York Central Lines
Standard Oil Company of New Jersey
The New Jersey Zinc Company
United States Steel Corporation
Western Electric Company
Westinghouse Electric & Manufacturing Company

A large number of others, including Cadillac Motor Car Company, Dodge Brothers, General Motors Corporation, Standard Underground Cable Company, the Pull-

A Survey of the Situation

By A. B. PARSONS
Associate Editor

SCRAP *Affects Markets for Virgin Metals*

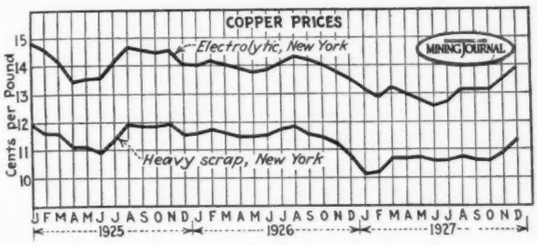


Fig. 3

man Company, and International Nickel Company, though not represented, advised that they were interested.

5 Many large industrial corporations in recent years have established new, or elaborated and reorganized old, salvage departments, to the end that no material will be definitely discarded unless winning a profit from salvaging is hopeless. Railroad, motor car, public utility, electric manufacturing, and machinery companies have been leaders.

6 The so-called "junk" business has been revolutionized in some respects.

7 Technical methods for treating scrap, discards, dross, and various residual products of manufacturing and industrial plants have been developed and improved. Large metal companies such as National Lead, Nichols Copper, International Minerals & Metals, American Metal, and Aluminum Company of America have become, directly or through subsidiaries, important factors in the salvaged-metal industry.

A brief outline of the organization of the scrap-metal industry will help to simplify comment on the statistical data. The itinerant junk collector still exists; and he continues to be an important factor in the business. His function is to gather up material that has outlived its usefulness from the general public, the ultimate consumer of manufactured goods. He buys as cheaply as he can and sells for all he can get, sorting his material roughly and selling small lots, depending on casual inspection to ascertain the value. Next comes the small dealer or wholesaler. He buys from the junk man, sorts and classifies his metals and alloys, accumulates larger lots of different kinds, and sells to a larger dealer or trader, who may further classify and combine, selling finally in carload lots either to smelters or melters. The distinction is a nice one; the smelter mixes charges, uses fluxes, and usually makes a pure metal or an alloy of different composition from any of the materials he feeds to his furnaces. The melter simply fuses alloys or metals, and casts pig or other shapes for resale; or he may be a manufacturer who buys good clean scrap to use in his own foundry.

A different channel through which old metal gets back into use is the salvage departments of the large industrial corporations. They reclaim thousands of tons of metals, some of which are used in the identical plant where they originate, some of which may be sent to the other plants controlled by the same company, and some of which may be sold either to the larger waste-metal dealers or to the smelters. The disposition depends naturally on the method that realizes the largest profit.

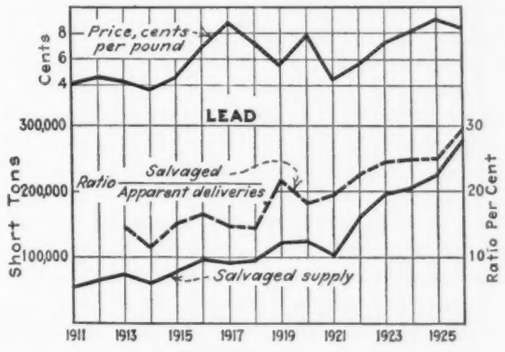


Fig. 4

Recent years have been marked by a trend toward more careful sorting and classification on the part of the companies that "produce" the scrap, and the direct sale to "consumers" of scrap—namely, the smelting or foundry companies. The dealer who used to come to the plant and haul away a few truck loads of miscellaneous scrap is a less prominent part of the picture than he was, so far as the big sellers are concerned. It is important to bear in mind that the quantity of reclaimed metals supplied by the big manufacturing, railroad, motor car, public utility and industrial companies does not by any means overshadow, in the aggregate, that supplied by the millions of households and small businesses.

In the upper strata, at least, the scrap-metal industry

Value of Metals From Salvaged Sources in 1926

Estimates by J. P. Dunlop, U. S. Bureau of Mines

Copper, including that in alloys other than brass	$78,876,000
Brass scrap, remelted	65,918,000
Lead as metal and in alloys	44,368,000
Zinc as metal and in alloys other than brass	11,700,000
Tin as metal and in alloys and chemical compounds	42,511,500
Antimony as metal and in alloys	5,164,400
Aluminum as metal and in alloys	23,868,000
Nickel as metal and in non-ferrous alloys and salts	2,135,000
Gold and silver	36,600,000
Platinum metals (conjectural)	3,000,000
Total	$314,140,900

in recent years has made great progress in improving the character of its business dealings. The old basis of most transactions was *Caveat emptor* — let the buyer beware. Profits in a measure depended on how cute

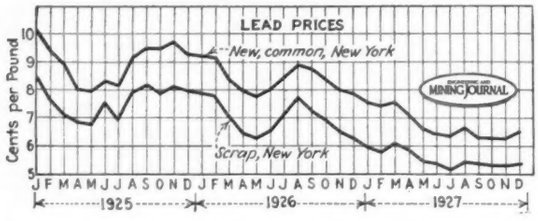

LEAD PRICES
New, common, New York
Scrap, New York
Cents per Pound
MINING JOURNAL
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1925
1926
1927

Fig. 5

the seller happened to be. Square dealing had no place in his business code. Today conditions are greatly improved. Large "consumers" of scrap often—perhaps generally—buy on the basis of sampling and assay, just as ores are purchased. Incidentally, a highly specialized technique has been developed for the accurate sampling of dozens of classes of old materials that for one reason or other present serious difficulties. One other development is the increased use of more complex alloys of non-ferrous metals. In addition to the major metals one finds chromium, molybdenum, tungsten, vanadium, sodium, and calcium in the present generation of alloys. This has complicated the technique of reclaiming.

The National Association of Waste Material Dealers has drawn up a set of standard specifications for old metals, classifying and defining in a rather broad way 36 kinds of scrap or waste products. It also has established rules regarding weights, delivery, and rejection, and provides for the settlement of disputes between members by an arbitration committee established by the association. It has been instrumental in developing business ethics that approach those of other industries.

With this picture of the salvaged-metal industry in mind it is not hard to imagine the difficulties that confront J. P. Dunlop, of the U. S. Bureau of Mines, in collecting and compiling the statistics that form the basis of most of the graphs in this article. He receives reports from about 600 companies, including "producers" of scrap, smelters, refiners, operators of foundries, and other users. Opportunities for duplication arise. Likewise some metal probably is reported as reclaimed that properly should be regarded as "in process." For example, new clippings that are melted in a manufacturer's own plant and used by him are not supposed to enter the data compiled by Mr. Dunlop, though they sometimes do. On the other hand, if a public-utility company replaces an obsolete transmission line with a larger one, the old wire properly should be regarded as part of the salvaged supply. Mr. Dunlop has written me that in his opinion his estimates of the quantity of metals recovered err in

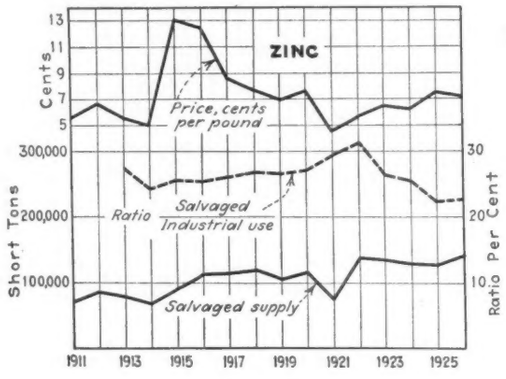


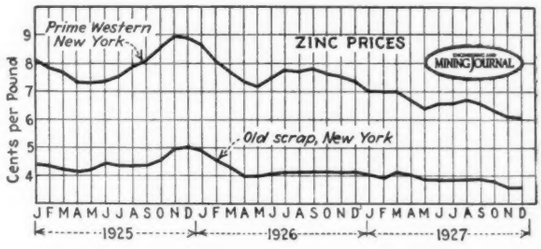
Fig. 6

the direction of being low rather than too high. He points out that at best the figures can never be anything more than approximations.

Referring to the set of seven charts showing the ratios existing during the last ten or fifteen years between the apparent consumption of virgin metals and the supply of salvaged metals, it is probable—in some instances certain—that the figures for virgin metal include some that actually is salvaged. Several primary smelters handle scrap metal, and as the identity of the scrap is lost after it gets into a furnace it is likely to turn up both in fact, and in the statistics, as virgin metal. This statement is borne out by the fact that in 1926, for example, the world's "virgin" copper production increased over 1925 as follows: mine, 3 per cent; smelter, 4 per cent; refinery, 6 per cent. Any discrepancy of this nature that existed, obviously would tend to indicate a ratio between salvaged and virgin supply lower than the actual. Subject to these limitations, the curves can be accepted as trustworthy reflections of the conditions in the salvaged-metal industry.

Sources of scrap copper are public-utility installations, which are constantly being torn down or dug up; old automobiles; buildings wrecked to make way for new ones; industrial and manufacturing operations of various kinds; obsolete electrical equipment; and other obsolete machinery. In addition, the data for copper include the copper content of brass—of which there are dozens of grades. Aside from the sources mentioned above, all of which account for brass as well as for copper, special

Fig. 7


Prime Western New York
ZINC PRICES
Old scrap, New York
Cents per Pound
MINING JOURNAL
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1925
1926
1927

mention should be made of automobile radiators—forming a sizable salvaging industry by themselves—and the skimmings, ashes, sweeps, spatters, turnings, grindings, and clipping from brass foundry and fabricating plants.

From salvaged copper and brass the principal products are ingot brasses of a variety of grades, some of which can be used for rolling; casting copper; or high-grade electrolytic copper. In one or two smelting plants some of the zinc from brass is volatilized and recovered as an oxide. The electrolytic copper is entirely comparable with that made from new blister, and the casting copper commands a good market at about ½c. per pound under electrolytic. It is estimated by competent authorities that 75 per cent of the fabricated copper in ordinary use might well find its way into the salvaged supply. The facts that copper and brass do not rust, that they are not used as pigments or for other "destructive" purposes, and that the value is higher than that of lead or zinc, help account for the relatively high proportion reclaimed.

Aside from showing the large tonnage salvaged in recent years, Fig. 1 discloses the interesting relation between price and salvaged supply. Three troughs in the price curve—in 1914, 1921, and 1924—are precisely duplicated in the curve of salvaged supply. Peaks in 1917 and 1923 likewise coincide. It seems a fair deduction that the increase in the quantity reclaimed in 1926 was the consequence of the improved technique of buying and treating

scrap, in conjunction with the large supply that became available as a consequence of the large expansion of consumption in the preceding five years. It is believed that a still further increase in salvaged supply will be shown by the figures for 1927.

One interesting phase of the situation is the remarkable increase in exports of scrap brass and particularly of copper. The figures for 1927 are approximately 47,000 and 21,000 tons respectively, a total about twice as large

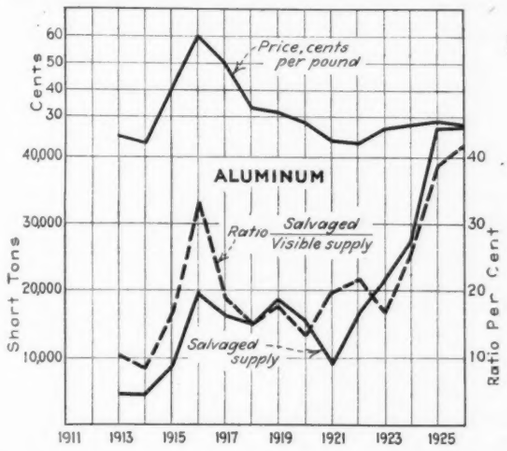


Fig. 8

as that of the preceding year. To Copper Exporters, Inc., is attributed much of the keen appetite of Germany and other European countries for scrap of this character. Foreign dealers were driven into trading in scrap by the inability or difficulty in getting virgin metal. No doubt the competition from buyers on foreign account lent strength to the domestic market.

Fig. 3 shows graphically dealers' buying prices for heavy scrap and prices for electrolytic. These have paralleled each other closely during the last three years. However, the sag in electrolytic in the second quarter of 1927 was not accompanied by a corresponding movement in scrap. Dealers' buying prices used in the charts for copper, lead, zinc, and aluminum are those published by the *American Metal Market*. It is probable that the

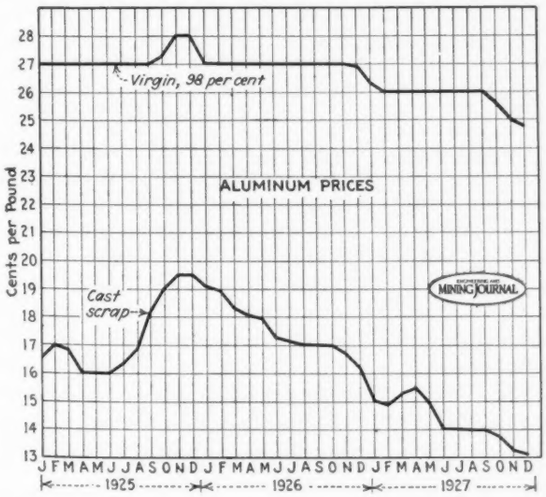


Fig. 9

actual prices paid were somewhat higher, as the competition among buyers has been very keen and they doubtless paid more than they reported to the trade papers as their offering prices. All other price data used herewith are taken from the official figures of the *Engineering and Mining Journal*.

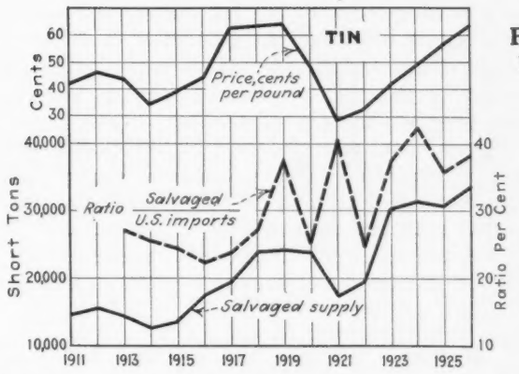


Fig. 10

Salvaged lead comes principally from the following sources: storage batteries, including plates, red lead, and litharge; discarded lead-covered cables; scrap and dross from babbitt metal, solder, and type metal; plumbing scrap; scrap from manufacturing; and ammunition from shooting galleries and armories. When the price was high the surface of trap-shooting ranges was scraped up, screened, and concentrated pneumatically at a profit!

Doubtless the acute upturn for 1926, shown in Fig. 4, is accounted for principally by the increased number of storage batteries reclaimed. About 90 per cent of the lead used in batteries is salvaged; and as the life of batteries is estimated to average only about eighteen months, the huge number of batteries used for automobiles and radios in 1924 and the early part of 1925 appeared for reclaiming in 1926. Much the same situation doubtless obtained in 1927.

Another factor that operated in 1923, 1924, and 1925 was the advancing price for lead. This naturally stimulated the collection and offering of scrap right down the line to the retail junk dealer. It will be interesting to see, when data are available, to what extent the lower average prices prevailing in 1927 may have affected the tonnage of salvaged metal. Lead used in the manufacture of paint is not reclaimed, and that fact tends to keep down the ratio of salvaged to virgin metal. In Fig. 5 it may be seen that since March the spread between the price for new and reclaimed lead has narrowed somewhat, suggesting that when a certain minimum price level is reached offerings of scrap lead will shrink.

Used brass and other alloys is the chief source of salvaged zinc; second is dross, skimmings and ashes from galvanizing operations. In addition, these byproducts of galvanizing are used to make zinc dust, lithopone, and zinc chloride in large quantity. In Fig. 6 only metallic zinc and the zinc content of brass and alloys are considered. About 45 per cent of the zinc used in the United

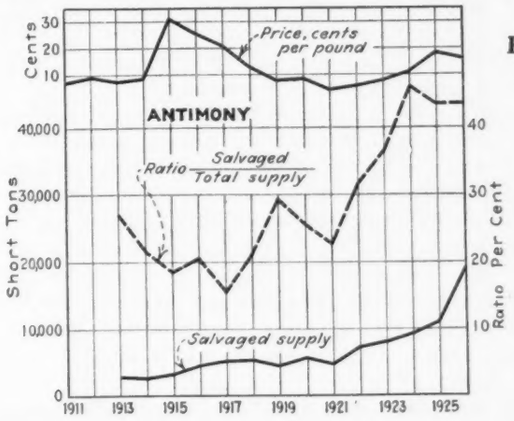


Fig. 11

States is accounted for by the galvanizing industry; and from the nature of galvanized products it is obvious that very little is ever reclaimed. Moreover, a considerable proportion of the zinc in salvaged brass is lost in the smelting process; and a good tonnage of zinc goes into paint pigments and into zinc dust for the cyanidation of gold and silver ores. The comparatively low ratio of salvaged metal is accounted for by these facts. Fig. 6 shows that even the extremely high prices of the war period did not greatly increase the quantity reclaimed; nor did the excellent market that continued from 1923

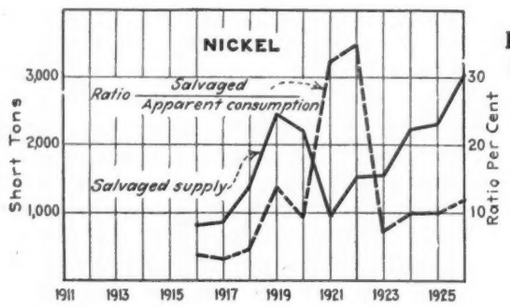


Fig. 12

through 1926. Much the same condition as existed with respect to lead in 1927 is shown in Fig. 7: that is, the margin between Prime Western and scrap narrowed, apparently because of the resistance of the scrap to decline when the price was around 4c.

The automobile—potent influence in so many industries—probably lies behind the rapid rise in the quantity of aluminum salvaged since 1923. Half of the total is as unalloyed metal; the remainder principally as No. 12 alloy, containing 92 per cent aluminum and 8 per cent copper. Both of these, in late years, have been used extensively in automobile manufacture, and the scrapping of cars since 1923 has thrown the metals onto the market in increased quantity. Fig. 9 reveals a peculiar condition. The market for virgin aluminum was slow throughout 1926 and 1927. Prices for new metal were cut three times as indicated, the net decline being only about 3.2c. Cast scrap weakened persistently, except for one brief rally, and in the same period showed a net decline of about 6.5c. With important new sources of virgin aluminum about to come into production, it seems reasonable to look for still further reductions in the price.

Three important sources of salvaged tin may be mentioned: drosses, incidental to the making of tin plate and terne plate; scrap alloys, including bronze, pewter, babbitt, electrotype metal, and solder; and scrap tin-plate, principally new, as distinguished from old tin-plated containers. The products are pig-tin, alloys—chiefly with lead; and chemical compounds—principally tetrachloride, bichloride, and sodium stannate. Of the three the lead alloys account for the largest tonnage. In one plant handling lead and lead-alloy scrap, electrolytic tin, of 99.75 per cent purity, is made. The tin compounds are chiefly the product of detinning operations. Fig. 10 discloses a rather definite tendency for the quantity salvaged to fluctuate with the price.

Virtually no unalloyed antimony is used in industry. With lead it is a constituent of numerous alloys—babbitt, battery plates, solder, and type metal—that are readily reclaimed, a fact that explains the relatively high ratio of salvaged supply. In this respect it is second only to copper. Antimony is recovered almost entirely as antimonial lead, the antimony content ranging between the extremes of 3 and 30 per cent. The marked similarity between the curves showing the quantity of salvaged lead, and salvaged antimony, as shown in Fig. 11, is as might be expected.

Wider use of nickel non-ferrous alloys, including monel metal, nichrome (nickel 60 per cent, chromium 40 per cent) and nickel silver, has resulted in the increased quantity of nickel reclaimed. Fig. 12 shows this growth; and incidentally reflects the trend of consumption of virgin nickel. In 1921 a total of 900 tons salvaged was 32 per cent of apparent consumption; whereas in 1927 a total of 3,100 tons was only 12 per cent of consumption.

Summarizing the situation, it is evident that the salvaging of metals is an industry that has grown rapidly in recent years and that may be expected to expand still further. It will contribute in increasing proportion to the requirements of industry for metals. This tendency is economically sound, and it could not be stopped even if producers of primary metals wanted to stop it. Available statistics indicate that the production of copper in the United States has totaled nearly 19,000,000 tons, of lead more than 17,000,000, and of zinc about 10,500,000; and these figures are being added to every year. Of these quantities large proportions, increasing in the order in which the metals are named, have been lost or dissipated beyond recall; on the other hand, particularly with respect to copper, the quantity still in use is enormous. One wonders, if an emergency arose, how much could be recovered and collected in the United States!

Perhaps the most tangible influence of the actual and potential supply of reclaimed metal is the strong tendency to stabilize the market. Any drastic advance in prices would bring out large supplies of metal from salvaged sources; and, on the other hand, a serious slump in prices would in all probability be followed by marked contraction in the "production"—or at least in the offerings—of salvaged metal. In this connection one peculiar condition deserves emphasis. The individuals engaged in the waste-material business are for the most part of Semitic extraction; they are essentially traders, who invest their money in tangible goods, and they are willing to hold them until they can sell at a profit. This applies to the "junk" collector and to some extent to the successive group of dealers. In periods of low prices, large stocks of salvaged metal tend to accumulate in the hands of these dealers, and pressure is consequently kept off the market.

But entirely aside from this, a material decline in price would tend to diminish the quantity gathered up from original sources. Although a large part of the salvage supply is "low-cost," another large proportion costs, before it is put into marketable form, close to the selling price. Any major decline would automatically cut off this "production," and this would be done without entailing the painful necessity of shutting down anybody's mine.

Such an effect of curtailed supply appears to be exemplified in the behavior of the markets for lead and zinc in 1927, as already pointed out. The one mitigating circumstance in connection with the entire subject is that which has been mentioned—namely, the fact that salvaged metal acts as an effective stabilizer of the market. The mining industry is faced with a condition that neither can nor—looked at fairly—should be changed. The only thing to do is to take it into account in formulating plans and policies in producing and marketing virgin metals.

Two-Fan Installation for Ventilating *Mine Workings*

By WALTER S. WEEKS
Professor of Mining, University of California

IN MANY MINES the temperatures are such that the cooling power of still air is so low that little manual work can be done; but if the air is moving the cooling power is adequate. Saturated air at 80 deg. F. is stifling if the air is still, but is comfortable for work if given sufficient velocity. The object of this paper is to discuss an economical method for increasing velocities.

If efficient work is to be done, the cooling power of the air should be such that a man can labor continually without much rise in body temperature. If more heat is produced by the body than can be removed by the air, the body temperature rises, and the man must stop work to cool off, although he may not be tired. It is a short-sighted policy on the part of any management to permit such a physical limitation of labor if it can be removed easily. In many cases the limitation can be removed by merely moving the air, and the cost of moving it is negligible compared with the gain in the efficiency of labor. Much time and money may be spent in increasing the efficiency of some machine, but compared with the saving that can be effected by increasing the efficiency of the worker, it is like trying to save money in the boarding house by using fewer yeast cakes.

To maintain high velocities a large volume of air must be circulated. The cost of circulation depends on the length and condition of the path which the air must travel. In many deep mines, the shafts were not designed with the ventilation problem in view. The secondary exit often consists of a series of small raises maintained through worked-out stopes. With such conditions a tremendous expenditure of power is necessary to force sufficient volume of air from the surface to insure sufficient velocity for cooling in the lower workings. The high pressures accentuate the waste of power by leakage.

Mechanical ventilation may be used to accomplish any or all of the following objects: (1) To maintain sufficient chemical purity for breathing; (2) to remove dust and powder smoke; (3) to cool the worker; (4) to lower the rock temperature; (5) to dilute and remove poisons or explosive gases; (6) to control air currents in case of fire or explosion. The one of these objects that requires the most air determines the amount that must be circulated. If this requirement is satisfied, there will be an oversupply for the others.

Let it be assumed that the ventilation needs are enumerated in reasons 1, 2, 3 and 6, and that the air in the mine is saturated at 80 deg. F. The amount of air necessary for breathing is small. About 10 cu.ft. per man per minute will keep the oxygen content of the air at about 20 per cent; 40 cu.ft. per man per minute will keep the carbon dioxide content of the air at about 0.3 per cent. The only effect of small amounts of carbon dioxide in the air is to increase slightly the rate of breathing. An allowance of 50 cu.ft. per man per minute for breathing is ample. To remove powder smoke and dust a velocity of 30 cu.ft. per minute is sufficient. If it is assumed that the cooling power of the air as measured with the wet kata should be 250 B.t.u. per

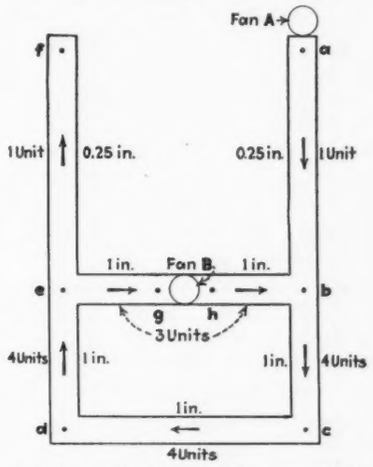


Diagram showing short-circuiting ventilation system

square foot per hour, the air velocity with saturated air at 80 deg. F. should be about 250 ft. per minute.

The amount of air necessary for cooling usually far exceeds the amount for the other requirements, so it would seem reasonable to place one fan on the surface to force enough fresh air into the mine to keep the air reasonably pure and to remove smoke, and to place another in the mine close to the active workings, short-circuiting a large amount of air for cooling.

In the accompanying sketch the scheme is shown diagrammatically. The crosscut *b*—*e* is just above the active workings and the workings are represented by crosscut *c*—*d*.

Direction of the air currents is indicated by arrows. The amount of air circulating is expressed in an arbitrary unit. The pressure drop in each section is assumed to have been calculated and is shown by the small figures in inches of water.

Assume that 1 unit of air is to be forced from the

surface by Fan A, and 3 units are to be short-circuited by Fan B, which arrangement will cause 4 units to circulate in the lower workings. The problem is to determine the pressure against which the fans must operate so that the fans can be specified.

Atmospheric pressure will be considered as zero and the pressure in the mine will be designated "plus" if above the atmospheric pressure and "minus" if below. In working out the pressures in the mine always start at the point where the mine is open to the atmosphere, for the pressure there is the only one that is known.

The pressure at *f* is 0. It requires 0.25 in. to force one unit from *e* to *f*, so the pressure at *e* is +0.25. It requires 3 in. to force 4 units from *b* around to *e* via *c*—*d*, so the pressure at *b* is +0.25 + 3 = +3.25. It requires 0.25 in. to force 1 unit from *a* to *b*, so the pressure at *a* is +3.25 + 0.25 = 3.50. This is the water gage at which the Fan A must work. It requires 1 in. to force 3 units from *e* to *g*, so the pressure at *g* must be 1 in. lower than at *e*, where the pressure is +0.25. The pressure at *g* is —0.75 in. It requires 1 in. to force 3 units from *h* to *b*, so the pressure at *h* must be 1 in. higher than at *b*. The pressure at *h* must be +4.25.

Fan B takes the air at —0.75 in. and raises it to +4.25 in., so the fan is working at a water gage of 5.0 in.

The same results may be obtained by making the surface fan an exhauster. Consider Fan A to be an exhauster placed at *f*. The directions of the air currents will be the same as in the previous case. The pressures at the different points are given in the following table:

Point	Pressure	Point	Pressure
a	0	e	—3.25
b	—0.25	f	—3.50
c	—1.25	g	—4.25
d	—2.25	h	+0.75

Fan A works at a negative pressure 3.50 in. and Fan B raises the air from —4.25 to +0.75, a total of 5.0 in. The fan pressures are the same as in the previous arrangement.

It now becomes interesting to compare the amount of power used by this two-fan system with that used by a single fan at the surface circulating 4 units through the lower workings. As the power required by a fan is proportional to the pressure times the volume, it is necessary only to compare these products.

If one pressure fan at *a* is doing the work, the crosscut *b*—*c* is closed. As it takes 0.25 in. to force one unit from *a* to *b*, it will require $\left(\frac{4}{1}\right)^2 \times 0.25 = 4$ in. to force 4 units from *a* to *b*. Likewise, it will require 4 in. to force 4 units from *e* to *f*. The pressure at the fan is then 11 in.

Power = $p \times v = 11 \times 4 = 44$.

With the two fan systems, the power used by Fan A is $3.5 \times 1 = 3.5$ and by Fan B is $5.0 \times 3 = 15$.

Total power with two-fan system, 18.5.

With the specified conditions, less than half the power is used with the two-fan system. The saving of course will vary with each mine.

To determine whether the air would really flow as the theory indicated, Karl M. Stewart and John C. Fitzpatrick, students at the College of Mining in the University of California, made some tests on a model mine arranged as in the sketch. The ducts were of pipe with regulators inserted in them to increase the resistance. The fans were equipped with variable-speed motors. Air velocities were measured with the Pitot tube. They found that they could predict accurately the speeds at which the fans should be run to cause any desired distribution of the air.

The ducts were divided into sections and the pressure-volume characteristics[1] of each section plotted. A characteristic of each fan was determined at one speed and characteristics at other speeds were plotted.

Any distribution of air could be assumed and the pressure drop through each section read from the curves. The pressures at which the fans should operate were then computed as has been shown. The speed at which the fans should run to give the required amount of air could then be read from the chart of the fan characteristics.

In the installation of a short-circuiting system certain details must be considered. Provision must be made for closing the crosscut in which Fan B is situated. During the removal of powder smoke Fan B is stopped and the door in the crosscut closed. The surface fan then causes a thorough circulation, which carries out the smoke. The fans should be equipped with variable-speed motors so that the speeds may be adjusted to give the desired division of air. It is impossible to predict exactly the speed at which the fans should run, because of the irregularity of mine openings and the effect of leakage. The surface fan should be able to circulate the necessary air for breathing and removal of smoke and should possess a liberal speed allowance to care for the unknown leakage between shafts. It must be remembered that the fans are operating in parallel, so unless the working points are on the steep parts of the characteristics the fans will be in unstable equilibrium. Fans with backward-turned blades are best for parallel operation.

The surface fan should be reversible for control in case of fire. If a fire occurs the short-circuiting fan must be stopped and the crosscut closed. The fan can be stopped by shutting off the power at the surface. The doors in the crosscut should be held open by an electrical device actuated by the current from the fan motor. When the fan is stopped the doors should close by means of a weight and should latch. Air currents in the mine are then under control with the surface fan.

One point remains to be considered—namely, the effect of short-circuiting on the dust content of the air.

The new air entering the mine causes a dilution. Referring to the sketch assume that 1,000 particles of dust per unit of air are produced in workings *c*—*d*. One-fourth of the particles pass up the upcast, so 3,000 particles enter the short-circuiting fan. At point *b* a unit of clean air enters, so that the dust content between *b* and *c* is 750 particles per unit of air. This is on the assumption that no dust is removed in transit.

It has been noted that an extremely small proportion of the dust that is produced ever leaves a mine. It gets caught on the timbers and rocks. If special provision were taken to entrap the dust in crosscut *b*—*e*, I believe that most of it could be removed. If the air in the mine is saturated, air washers using mine water could be installed. This would not change cooling conditions if the water were at the same temperature as the air. If, however, the mine air is not saturated, it would be poor policy to humidify it. In such a case it is quite possible that a series of baffles composed of burlap soaked in some deliquescent solution might comb out most of the dust.

[1]Duct and fan characteristics are discussed in "Ventilation of Mines," by W. S. Weeks. McGraw-Hill Book Company, 1926.

Fundamental Factors Underlying

Electrical Methods of Geophysical Prospecting

With Special Reference to the Inductive Processes

CONCLUDING INSTALLMENT*

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EFFECTS OF PHASE RELATIONSHIP between primary and secondary fields will next be considered, beginning with "in-phase" conditions. If the primary and secondary fields both arrive at the receiver so that they reach their maximum and minimum values simultaneously, they are said to be in phase. Under such conditions a definite resultant can be obtained for any given ratio of primary to secondary fields; and sharp definite minimum readings can be obtained with the direction-finding loop. If the primary and secondary fields are represented by vectors of proper length and drawn at an angle to represent their respective directions, a single vector resultant will be obtained. The length of this resultant vector and its angle with each of the component fields is definite.

Often, however, the two fields are not in phase in geophysical work, and especially is this true when using the higher frequencies. In such a case a single resultant vector cannot be obtained. The length of the vector and also its direction will vary within wide limits. The locus of the end of the resultant vector during one cycle is then an ellipse, and sharp definite minimum readings cannot be obtained. Such an "out-of-phase" condition is readily recognized in practice, and the remedy, of course, is to shift the energizer frequency until the proper relationship is obtained at the point where the readings are being made.

A shift in the phase relation between primary and secondary fields is due largely to the following factors: average depth of the orebody as compared to the distance between energizing and receiving equipment; distortion of wave front and difference in velocity of propagation between air (through which the primary field travels in reaching the receiver) and the earth (through which the energizing and the secondary field travels); transformer action; and distribution of current in the conductor.

When working at the higher frequencies, the phase relationship between the primary and secondary fields becomes of increasing importance. When working at low frequencies, say 500 to 1,000 cycles, there is often only a slight shift in phase between the two fields. At a higher frequency the phase shift may be of sufficient magnitude to introduce a serious error in the indicated direction. Errors of 10 or more degrees due to phase relations may be encountered in field work.

In the case of a 60-kc. wave, the phase difference due to difference in velocity of propagation alone is sufficient to cause a serious error in the resultant direction. The actual direction is dependent upon the phase angle and the relative strengths of the two fields. It will also be difficult for the operator to obtain an accurate direction of the minimum, owing to the lack of sharpness or the broadness of the signal. In the case of a 500-cycle wave the phase shift is negligible for practical work. Frequencies of less than 5,000 per second are not concerned with phase displacement, because these effects usually are of such small magnitude as to be negligible.

For the ideal case illustrated in Fig. 2, of a simple wire in air, the wave travels outward from the wire in true circles. Under such conditions, the direction-finding coil can be used to locate accurately the position of the wire where two or more different readings have been made. In actual practice, however, the wave front traveling outward from the conductive orebody is not a true circle, and the conductor cannot be located by the simple process previously described. The wave front is distorted because of the existence of three factors: size of the conductor, irregular current distribution in the conductor, and difference in velocity of propagation for the wave in penetrating different media.

As is well known, the velocity of propagation of an electromagnetic wave varies with the character of the media through which the wave passes. The relative velocity of propagation through any substance, as compared to air, may be expressed in an elementary way by the following simple relationship:

$$V = \left(\frac{V_o}{\sqrt{md}}\,K\right) + K'$$

in which: V_o = velocity of the wave in air
V = velocity of the wave in any other homogeneous medium
m = magnetic permeability of the medium
d = dielectric constant or specific inductive capacity
K and K' = Constants dependent on frequency effects, including hysteresis, eddy currents, and related factors.

*Part I appeared in the issue of Feb. 11.
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This simple formula cannot be used directly for obtaining the absolute velocity of the wave in any media. The constants are known for the comparatively minor distortion effects due to conduction, hysteresis, dielectric losses, eddy current losses, or other causes. These effects vary differently with the frequency. The formula neglecting the constants is, however, of sufficient accuracy to predict the approximate distortion of the wave front when traveling through various media. The specific inductive capacity of a substance varies with its conductivity; the greater the conductivity, the higher is the numerical value of d. A thick sheet of copper, for instance, will have a value of d which is almost infinity. A moist soil will have a much greater value of d than a dry desert soil. The distortion of wave front is therefore greater in moist regions than in the dry desert regions. Even in the same locality, the conductivity of different soils or strata varies within wide limits. The data in Table I were obtained from measurements made in the Pittsburgh (Pa.) coal fields.[1] Note the wide variation in conductivity between the surface soil, coal, and clay. Measurements made during research investigations in the Darwin mining district in California give an average value of $V = \frac{V_o}{4}$. Assuming the simple or ideal case, it may be stated that

$$\lambda = \frac{V_o}{f}$$

where λ = wave length
f = frequency
V_o = constant, commonly called the "propagation constant,"

which holds true for any homogeneous medium.

The effect of phase shift caused by difference in velocity of propagation can best be shown by a simple illustration. Consider an energizer generating a field whose frequency is 60,000 cycles per second, which *in air* is equivalent to a wave length of 5,000 meters. As previously stated $\left(V = \frac{V_o}{4}\right)$, a rough figure for the velocity of propagation of a subsurface wave is one-quarter of that in air. The value of V_o for air is 300,000,000 where the wave length is in meters and the frequency in cycles per second. One-quarter times 300,000,000 equals 75,000,000, which is the value of the propagation constant, and $\lambda = \frac{V}{f} = \frac{75{,}000{,}000}{60{,}000}$ or 1,250 meters wave length for the subsurface wave. Thus the phase shift, neglecting "transformer action" at a point 500 ft. from the source, will be $\left(\frac{500}{5{,}000} - \frac{500}{1{,}250}\right) \times 360$ deg. = 108 deg. phase displacement. If now we consider a wave whose frequency is 500 cycles, the resultant phase shift will be 0.9 deg.

A general form of equation for phase displacement would be $K + K'\left(\frac{D}{\lambda_o} - \frac{D}{\lambda_1}\right) \times 360$ deg. = phase displacement

where K and K' = constants; including "transformer action," frequency effects, and other factors
D = distance in meters from source to point observed
λ_o = wave length of wave in air
λ_1 = wave length of wave in other medium.

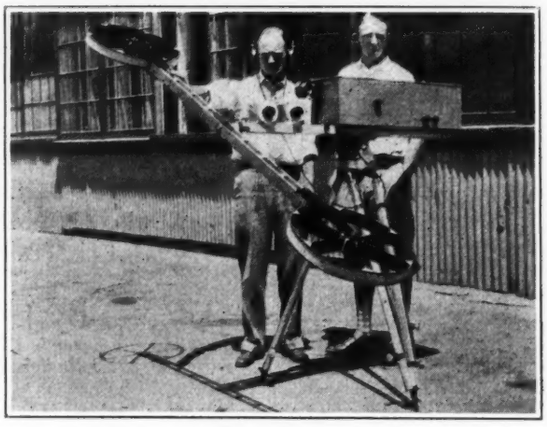


Fig. 6—The apparatus shown here was used for measuring wave-front distortion. It consists of a completely shielded, compensated antenna pick-up, receiver, and two coils rotatably mounted on a 6-ft. arm

Measurements were made of the wave-front distortion by use of the apparatus shown in Fig. 6. This apparatus consists of a completely shielded, compensated antenna pick-up, a receiver, and two coils rotatably mounted on a 6-ft. arm. A graduated arc and vernier are attached to the arm to allow direct reading of angles. The two coils are of identical electrical characteristics and so connected that their induced emf. are impressed upon separate input vacuum tubes. The output or plate circuit of these tubes is opposingly connected through a differential transformer. In making measurements, the apparatus is so placed that the axis of rotation for the arm carrying the two coils is parallel with the effective axis of the conductor. The arm is then rotated until zero signal is heard. At this point the two coils are so situated with respect to the wave front that the induced emf. in each coil is equal and also 180 deg. out of phase with each other, producing a zero signal. The angle which the arm makes with, for instance, the vertical,

[1]Jakosky, J. J. and Zellers, D. H.: "Factors Regarding Transmission of Radio Signals Underground." Reports of Investigations, U. S. Bureau of Mines; Serial No. 2651, November, 1924. Jakosky, J. J. and Zellers, D. H.: "Underground Radio." *Modern Mining Magazine*, January, 1925, pages 19 to 24.

Table I—Resistance and Conductivity of Certain Typical Strata to Electric Current

Material	Moisture, Per Cent	Soluble Material Grams per 100 Grams of Earth, Per Cent	Resistance in Field, Ohms (I = E/R)	Resistance in Solution, Ohms (I = E/R)	Conductivity in Field, Mhos $\left(C = \frac{1}{R}\right)$	Conductivity in Solution, Mhos $\left(C = \frac{1}{R}\right)$
Surface layer	14.2	0.112	1,778	2,666	0.000562	0.00075
Subsoil	10.8	0.032	1,193.5	4,444	0.000873	0.000225
Shale	1.1	0.048	5,264	3,077	0.00019	0.000325
Bituminous coal from experimental mine	2.1	0.446	4,255.31	1,315	0.000235	0.00076
Sandstone	1.8	0.0096	16,666	6,451	0.000062	0.000154
Freeport coal from Indianola mine	1.7	0.160	9,302.32	888	0.000174	0.001125
Slate	1.0	0.128	2,500	1,333	0.0004	0.00075
Pittsburgh coal from Verona	6.5	0.320	2,416	571	0.000414	0.00175
Clay	12.9	0.054	254.85	1,428	0.000393	0.0007

gives the angle of the wave front at that particular point, after balancing out the primary field.

In Fig. 7 is plotted the wave front for conditions similar to those prevailing at Darwin. It will be noted that the curve is not a circle after the wave emerges above the effective surface of the earth, plotted by assuming an ideal condition where the earth is homogeneous. With the secondary field alone present and the wave fronts as indicated, the position of the direction-finding coil for maximum signal strength will vary with the distance from the vertical position above the conductor. When immediately above the orebody the direction of maximum signal strength is downward, and toward the orebody. Secondary field readings taken at points on either side of the vertical position above the conductor will not give a direction toward the orebody. A reading made at, say, point *B* would give an intersection at point *b*. A reading at *F* will give an intersection at *f*, which is *above* the surface of the ground. By making readings on each side of the vertical position, it is possible to calculate the distortion and then locate the conductor. The accuracy of such calculations is subject to errors depending upon the depth of the body, relative conductivity of the different subsurface strata, topography, adjacent conductors, and related factors. An accuracy of +10 per cent is probably correct for bodies not more than 300 ft. deep. This, however, is usually sufficiently accurate for the necessary calculations required to locate the axis of the conductor.

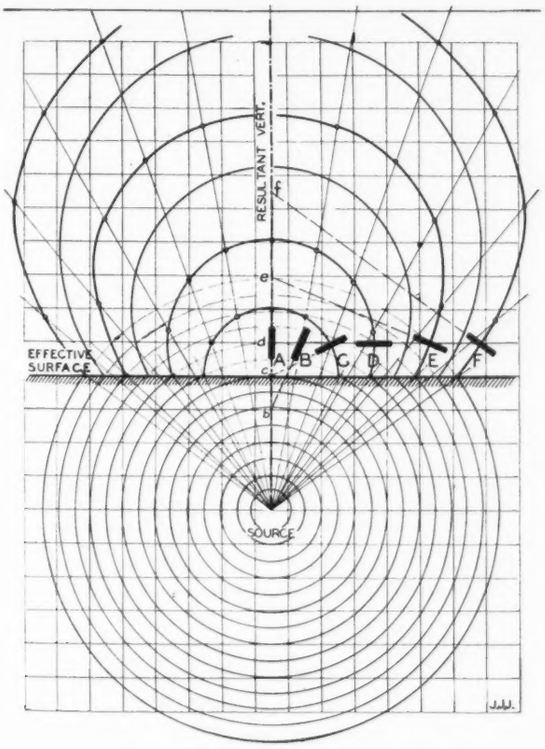


Fig. 7—Effects of wave distortion

The curves shown in Fig. 7 may, at first glance, seem to be in error, owing to the fact that intersections are seldom obtained in practice which intersect above the surface of the ground. It must be remembered, however, that the intersections obtained in practice are due to the resultant effects of the primary and secondary fields. The presence of the primary field (when vertically polarized as in the Radiore field procedure where a vertical energizing coil is used) usually causes the resultant intersections to be below the surface of the ground.

It will be noted that distortion of wave front tends to give an indicated depth *less* than that of the actual conductor. This factor will be considered later in the discussion of the correction curve.

Distortion of Primary Field

The primary field from the transmitter is also subject to distortion. This distortion is, as before, due to the difference in velocity of propagation of the different media through and over which the wave travels before reaching the direction-finding coil. The distortion of the wave front also varies among other factors with the height of the energizing coil above the surface of the earth.

In Fig. 8 is shown the calculated position of the wave front. It will be noted that the wave front is distorted near the surface of the earth, the amount depending upon topographic and certain other conditions. The two points *A* and *D* represent the instantaneous position of the wave front of some single wave. When traveling through air the wave has reached point *A* in the same time it has reached point *D* when traveling through the earth. It will be noted that distortion occurs regardless of the frequency employed in the energizing system.

Phantom Dips

Owing to the distortion of the primary field or improper alignment of energizing and receiving equipment, it often happens that a small (usually less than 20-deg.) "dip" is obtained. This is called a phantom dip, and is the angle which the direction-finding coil makes with the vertical when no secondary fields are present. If the energizing coil is placed vertical, the direction-finding coil will give a zero or vertical angle reading when the wave front is not distorted. These dips can be readily recognized by the experienced operator, however. In case of doubt, it is usually only necessary to move the energizer and note changes in angles.

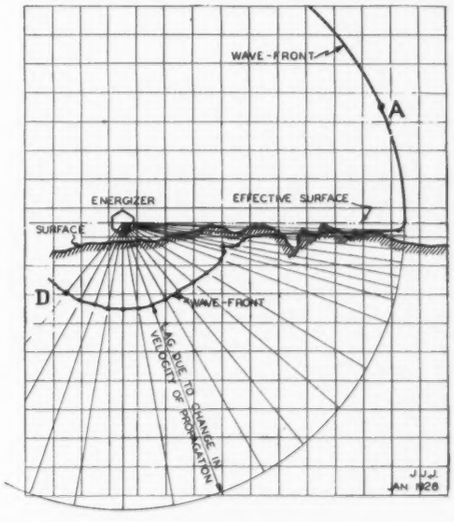


Fig. 8—Distortion of wave-front illustrated

Phantom dips do not, as a rule, give proper converging

lines. Such dips are obtained under proper conditions when the energizer and direction-finding coils are located on a ridge or in a narrow valley or canyon. The greater the distance between the energizer and the direction-finding coils, the greater is the wave-front distortion. Distortion of wave front and improper alignment of energizer and direction-finding coils can cause distortion, which can be understood by reference to the figure-eight curve of Fig. 9. The direction-finding coil is shown in the illustration pivoted on its horizontal axis. The wave front is shown as intercepting the coil at an angle with its axis of rotation. Under such conditions it can be seen that no magnetic lines of flux will thread through the coil, and we will obtain a zero signal. If, however, the coil is turned so as to have its plane at right angles to the plane of propagation of the wave, there is flux linkage. The polar diagram for such a condition is shown in the lower part of the figure. The same figure-eight curve is obtained, but its *minimum* is in the direction of the energizing coil. A comparison of these characteristics with the characteristics of the first figure-eight curve, shown in Fig. 4, will show that the minima are 90 deg. apart. If an attempt were made to locate a source of power when the wave front was so distorted, or when the energizer is located in a valley and the receiver on higher ground with its axis of rotation horizontal so as to have a fairly large vertical component, a big error would result. Taking a limiting case, if the wave front was vertical, a 90-deg. error would occur.

Referring to Fig. 10, we have an illustration of distortion of a wave front due only to the fact that the energizer was placed "back" and a little to one side of a hill. The heavy dot-and-dash line shows the position of the actual wave front. No secondary field is present. Note that the "strike" of the direction coil does not indicate the true direction of the energizer. The right-hand view (which looks from point *C* toward *O*) shows that the wave front is distorted vertically as well as horizontally. At that point a vertical distortion or phantom dip of 18 deg. is obtained.

Because of the comparatively short operating distances between the energizing and direction-finding coils in the application of the Radiore Company's method, together with the small size of the direction-finding coil compared to the operating wavelength, the field is almost wholly induction, with a minor radiation component.

The voltage induced in the orebody cannot be expressed by a simple relationship. The emf. induced in a conductor (with no radiation field present) is expressed by the following relation:

$$E = 2\pi fMI$$

where f = the frequency
I = the current in the energizing circuit, and
M = the mutual inductance.

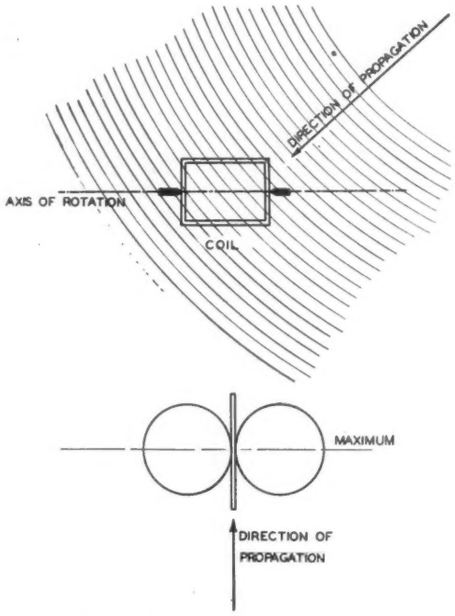


Fig. 9—Effects of tilted wave front

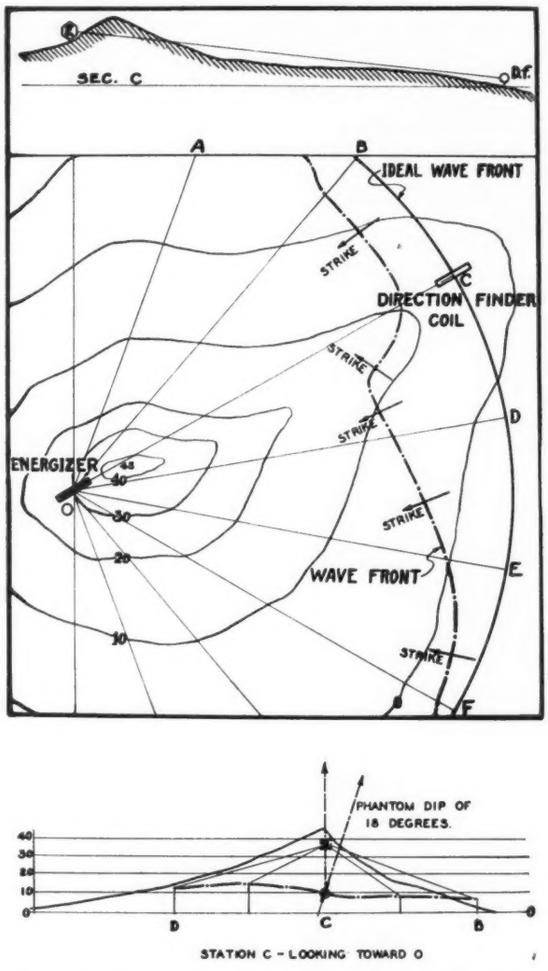


Fig. 10—Distortion of wave front caused by placing energizer "back" and a little to one side of a hill

The mutual inductance is a complicated relationship which varies with the distance, shape of the conductor, angle between conductor and field, and other factors. Various formulas for calculating the mutual inductance for simple shapes are given in textbooks.[2]

The voltage induced in the conductive orebody will cause a current flow, the magnitude of which will depend largely upon the effective resistance of the orebody. The current will flow along the conductor, and undergo much less attenuation than the original primary field. This may be explained in an elementary way by considering

[2]Also see "Radio Instruments and Measurements," Bureau of Standards, Circular No. 74, Section 69.

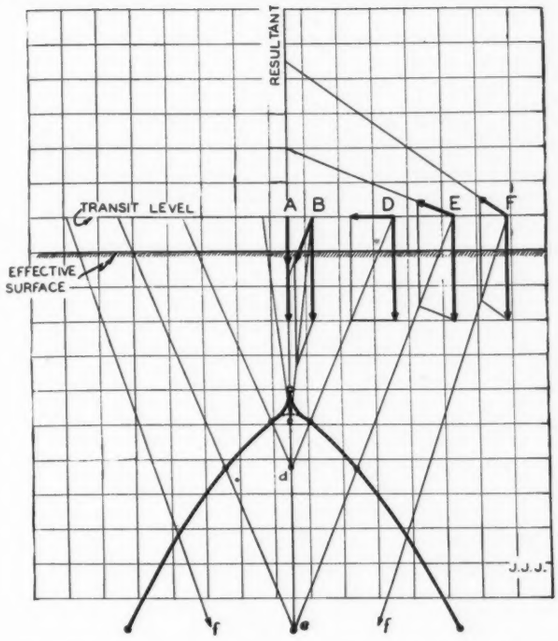


Fig. 12—By drawing a curve through the ends of the resultant vectors obtained by combining the vectors of the primary and secondary fields the location of the conductor can be determined

the induced current as traveling along the conductor by a "line radio" effect. In Fig. 11 is shown the relative audibilities, at various distances, for different types of insulated wire conductors. Another curve shows the calculated relative audibility for transmission through the air.[3] It will be noted that the signal strength of the wave (radiated field) traveling through the air decreases much more rapidly (inversely as the distance) than the waves traveling over conductors (oftentimes inversely as the square root of the distance). Detailed measurements have not yet been completed on long extended orebodies, but present available data indicate a rapid change in the ratio of primary to secondary fields as the distance between energizer and direction-finding coil is increased.

Plan Location. — By making a series of traverses, it is possible to locate the points (called "resultant verticals") above the conductor where the direction for maximum signal strength is vertical. Various methods are used in practice for location of these verticals. The simplest and the one used largely in reconnaissance surveying is actually to move the direction-finding coil along the traverse until the vertical is found. Light-weight receiving equipment allows the apparatus to be readily handled by one man, and rapid observations are possible. A fairly good operator can set up the apparatus, level the instrument, and make a reading (consisting of two readings, which are averaged, rotating the direction-finding coil 180 deg. to compensate for mechanical errors in the apparatus) in less than 30 seconds.

Graphic and special slide rule methods are used considerably on detailed work by taking readings at known distances apart over the traverse and then locating the vertical position by plotting the angles against distance, or by use of the calculating rule.

Location by Vector Curve.—Reference to Fig. 12 shows that the location of the conductor could be determined by drawing a curve through the ends of the resultant vectors obtained by combining the vectors of the primary and secondary fields. These resultant vectors, shown at *A, B,* and so on, are taken directly from the distorted wave shown in Fig. 7. The curve shown represents the conditions on a traverse across or over the conductor.

The shape of the curve varies with the relative strength of the primary and secondary fields. This may be noticed by referring to Fig. 13.

Curve A is obtained from the vectors when the primary and secondary fields have a ratio of nearly unity, whereas Curve B is obtained when the secondary field is about three times as great as the primary field. It will be noted that Curve A has a much longer "tip" than Curve B. In actual field operations where the measurements of these component fields is not usually made, the resultant directions only can be read, but no information is available as to the relative length of these resultants or the direction and ratio of secondary to primary fields.

[3]Jakosky, J. J. and Zellers, D. H.: "Line Radio and the Effects o' Metallic Conductors on Underground Communication." Reports of Investigations, U. S. Bureau of Mines, Serial No. 2682, April, 1925.

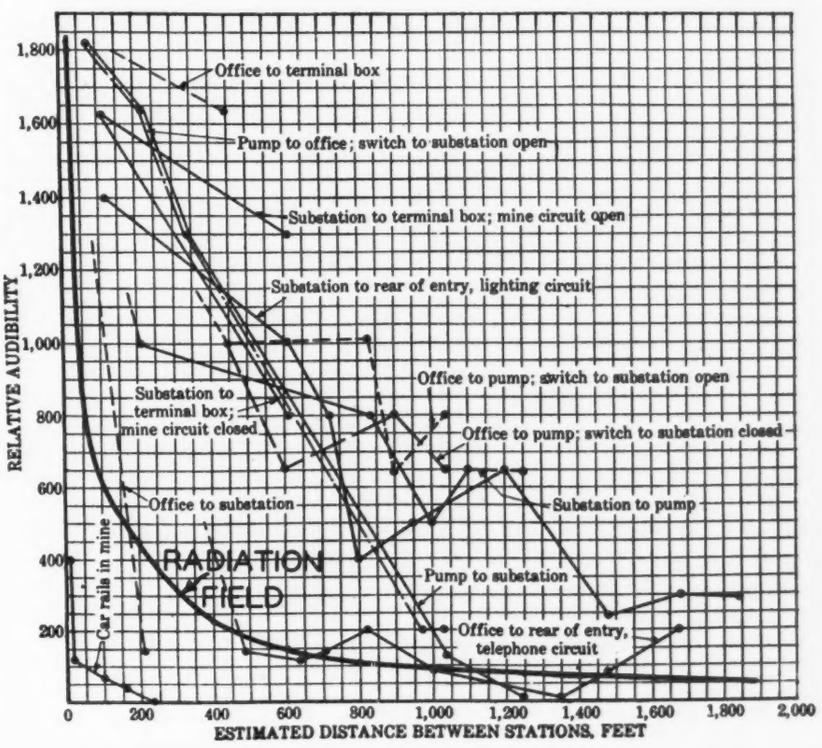


Fig. 11—Curve showing relative audibilities, at various distances, for different types of insulated wire conductors

The length and exact shape of the "tip" cannot therefore be determined.

Correction Curve.—To have a simple method for field use for ascertaining the approximate depth of the conductor, a *correction curve* was devised. This curve is empirical and was obtained originally by studying the

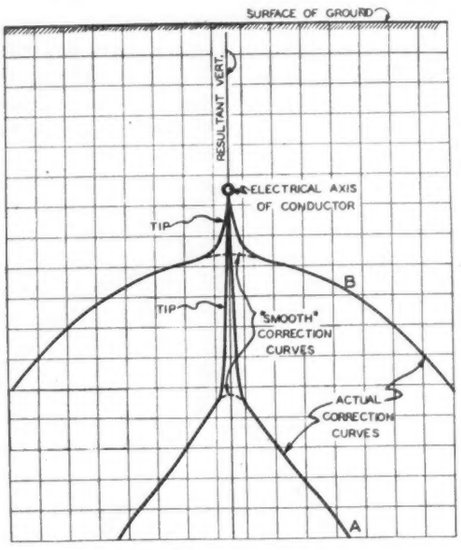


Fig. 13—The effects of tips. The shape of the curve referred to in Fig. 12 will vary with the relative strength of the primary and secondary fields

survey data of the experimental work at Darwin. However, during the past eight months it has been used in the United States and Canada extensively and found to be correct where checked by diamond drilling or mining to determine the actual depths and locations of the conductive orebodies. The two errors previously discussed (i.e., that due to distortion of wave front and that due to neglecting the "tip") are somewhat compensating. The results obtained by the correction curve are sufficiently accurate for general mining purposes at depths not to exceed 100 to 150 ft. For greater depths it is necessary to make additional measurements, entailing considerable time and calculation. Results obtained to date indicate that an accuracy of better than ±20 per cent is being obtained on depths to 300 or 400 ft. This percentage of accuracy is again sufficient for ordinary mining limits.

It must also be recalled that the electrical axis of a conductor usually lies within the body. If the orebody possesses a fair cross-section, a considerable error in the indicated depth will still allow the orebody to be found when an approximate depth indicated by the correction curve is reached. The vertical projections have also been found to be sufficiently accurate, even in the case of sheet or vein conductors located 200 to 300 ft. below the surface. The correction curve used in ordinary field work is shown in Fig. 14. Angles of maximum signal strength (although, as previously explained, *minimum* angles are actually read by the operator) are plotted to scale as ordinates at points (*A, B, C,* and so on) corresponding to their respective distances along the traverse. Perpendiculars are dropped from these points to intersect horizontal lines (*a, b, c*) drawn through the intersections of the resultant angles and the line RV, where vertical directions were obtained on the surface. By drawing a smooth curve through these lines, the location of the conductor is obtained where the curve intersects the line RV.

Plotting the *correction* curve as described virtually amounts to assuming that the secondary field vector is horizontal and that the primary vector is vertical. In this position the secondary vector is between the upward angle produced by distortion of wave front and the downward angle caused by drawing a smooth curve and neglecting the "tip." The relative magnitudes of the primary and secondary field vectors is taken into account in actual practice by proper distance of operation between the energizing and direction-finding apparatus. This distance is dependent upon the energizing power used, depth of orebody, type of mineralization, and other factors.

By ascertaining the depth of the electrical axis of the conductor at different traverses, it is possible to draw a profile view of the entire conductor.

Field Procedure During Detailed Survey.—After the conducting or mineralized area has been determined in the reconnaissance survey, a detailed survey is usually conducted to ascertain the depth of the electrical axis. The energizing apparatus is set up over the conductor and the plane of the coil is placed in the general direction or strike of the conductor. Six or eight readings are taken with the direction-finding coil at each traverse. The traverses are from 40 to 200 ft. apart, depending upon local conditions. During each set-up of the direction-finding and energizing apparatus the operators must have the energizing coil vertical, the plane of the energizing coil passing through the center of the direction-finding coil, and the axis of rotation of the direction-finding coil passing through the axis of the energizing coil. Resultant strike and dip angles are recorded.

Completed Survey Map.—The map of a typical electrical survey will show both a plan view and a profile view of a conductor or mineralized area. The "indication" in the plan view is tied in by the usual surveying methods to known property corners, bench marks, and other features, to allow later location of the *indication* should the electrical survey stakes be removed. In drawing the profile view of the conductor the depth of the conductor is obtained by plotting correction curves for traverses taken along the *indication*. By drawing a curve through the indicated depths at each of these traverses,

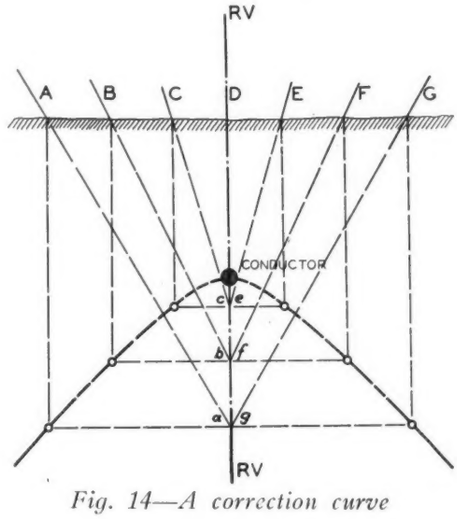


Fig. 14—A correction curve

the electrical axis of the conductor is located. The *correction* curves for each traverse are shown in the figure. These curves as shown are drawn by imagining the traverses as being rotated 90 deg. to allow the curves to be plotted in the plane of the paper.

In Table II are shown the results obtained by diamond drilling to date on indications obtained by the Radiore Company. Approximately 35 contracts have been completed, and information regarding the nature of the conductors is gradually being accumulated. Not until more complete reports are received, where diamond drilling is followed by actual mining, will data regarding the exact nature of the conductors be available.

Low Versus Radio Frequencies in Coil Systems

In some minds a great difference appears to exist between the so-called low-frequency methods (500 to 2,000 cycles per second) and the so-called "radio" methods. Extremely high "radio" frequencies—say above 1,000,000 cycles per second—have been found to be quite difficult to handle practically. At such high frequencies questions of phase relationship, distortion of wave front, and associated reflection phenomena become of considerable concern. When using the lower "radio" frequencies the behavior of the apparatus becomes quite different. Especially is this true when a coil is used for energizing the orebody, instead of an open antenna. A great characteristic difference between a coil and an open antenna is the *extremely* low radiation of a coil as compared to a straight lineal oscillator, a fact which is particularly true when the work is done at distances less than one-quarter wave length from the coil. For instance, the usual operating frequency range employed by the Radiore Company has a mid-point of 40,000 cycles per second. This frequency is so low compared to the size and design of the transmitting loop as to produce practically no radiation field.

Within the usual working distances of the loop, the radiation component may be entirely neglected, owing to compensating systems employed in the set-box. The system therefore operates under the same fundamental laws as any of the low-frequency systems. Frequencies on the order of 40,000 are, of course, harder to handle than the lower frequencies and require that more consideration be given the design of the equipment. The technique of operation is also more difficult, but to compensate for these disadvantages there are superior operating results which are not possible with the low-frequency or direct-current systems.

If a long, open antenna is used, the radiation component becomes of more importance and usually introduces errors in both the strike and dip readings which are not subject to compensation or mathematical correction.

Radiore Not a "Radio" Method

The name "Radiore" adopted by our company may be somewhat misleading to one not conversant with high-frequency phenomena. The frequency employed in our process, though relatively high, allows practically *no radiation component* in the vicinity of the energizing loop, owing to the small dimensions and other factors in the design of the loop. As a matter of fact, special precaution was taken in the design of the energizing equipment to minimize the radiated field and to make the magnetic or induction field predominant.

It is possible to have a field where radiation is by far the major energy component. The use of an open antenna, operating on 300 or more kilocycles as used in the so-called radio methods, produces a large radiated field. Such a system is more truly a "radio" method, although somewhat similar inductive direction-finding equipment is used as in the Radiore and the 500 to 1,000 cycles methods.

Table II—Results Obtained by Diamond Drilling on Certain "Indications"

No.	Property	Name or Number of Indication	Survey Data: Minimum and Maximum Depth, Throughout Length, Ft.	Survey Data: Electrical Effects	Remark Re Survey	Depth of Top of Conductor When Proved, Ft.	Thickness of Conductor	Method Used to Prove Conductor (a)
1	Defiance Extension	Snowstorm	23 to 70	Good	.....	55	10 ft.	Tunnel
2	Defiance Extension	Fork	65 to 140	Fair	.....	135	.....	Diamond drill
3	Defiance Extension	Colonel	40 to 90	Good	.....	50	.....	Tunnel
4	Abbey Mines	Outcrop	40 to 75	Very good	.....	50	20 ft.	Diamond drill
5	Abbey Mines	Premier	150 to 250	Good	Axis can be shifted 25 ft.	4, overburden	25 ft.	Trench
6	Abbey Mines	Base Line	150 to 300	Good	.....	75	.....	Diamond drill
7	Laval-Quebec Mines	Corner	100 aver.	Poor	Minor conductor	.....	3 in.	Diamond drill
8	Laval-Quebec Mines	Doubtful	.....	Poor	Minor conductor	.....	Thin seams	Diamond drill
9	Laval-Quebec Mines	Trench	150	Poor	Very weak	150	Thin vein	Diamond drill
10	Laval-Quebec Mines	Range	Over 200	Poor	Hard to trace	Unknown	Unknown	Diamond drill
11	Laval-Quebec Mines	No. 102	Over 200	Poor	Hard to trace	Unknown	Unknown	Diamond drill
12	Brownlee Gold Mines	No. E	60	Good	.....	Unknown	Unknown	Diamond drill
13	Brownlee Gold Mines	No. A	370	Poor	Hard to trace	354	Unknown	Diamond drill
14	Copper Hills Mines	No. 12	.....	Good	.....	20, overburden	Undetermined	Trench
15	Arno Mines	Birsh	12	Major	Pit dug by crew	4	Undetermined	Pit
16	Windfall Rouyn	Dome extension	125 aver.	Fair	Hard to follow	5	Undetermined	Trench

(a) In each of these sixteen surveys a conductor was located. The company in every contract reserves the right to publish the information as to whether or not an electrically conductive ore or area was located.

Advantageous to Use Higher Frequencies for Reconnaissance

Because of the better conductivity of a major portion of the mineralized areas (especially disseminated, broken, or faulted districts) at the higher frequencies, it is usually advantageous to employ a high-frequency process during reconnaissance work. Since the conductivity of many ores is greater at high frequencies, a greater current flow is obtained. This results in quicker detection and plotting of the mineralized areas, with a considerable saving in time. Once the mineralized areas are located by reconnaissance, the detailed work can be done by both the high- and the low-frequency or direct-current methods. High frequencies need not be applied inductively, but may be employed by the usual applied potential system of using electrodes contacting with the earth. The loop or inductive method is usually employed, however, because of its extreme portability and advantages in reconnaissance operations. A small reconnaissance direction-finding and energizing apparatus developed by our company is shown in Fig. 15 in the left-hand and middle views and is capable of working to depths of 75 to 100 ft. The left-hand view shows the small reconnaissance direction-finding apparatus. The energizer is seen in the center. This equipment, complete with set-box (containing rectifier, amplifier, battery supply and operating controls) transit, Brunton com-

pass, and complementary apparatus, weighs only 15 lbs. It is readily handled by one man. A small reconnaissance energizer is shown in the right view and weighs 19 lbs. complete.

On the right in Fig. 15 is shown the larger direction-finding apparatus used for making detailed cross-sections and also where the electrical effects from the conductor are relatively weak. This equipment consists of the direction-finding coil mounted on a small mine or mountain transit, a set-box, and compensating devices. It weighs approximately 25 lbs. and is also readily handled by one man. The small size of the equipment and its resultant light weight are possible because of the use of higher frequencies (40,000 cycles) in place of the lower 500 to 1,000 cycles frequencies. The direction-finding coil for 1,000 cycles necessarily must contain higher inductance for efficient operation. This coil alone weighs 11 lbs., compared to 5 oz. for the high-frequency compensated coil. Our company uses reconnaissance equipment of the high-frequency type, the low-frequency equipment being used in the detailed work to supply a supplemental survey. Study of the results obtained from the two methods gives information regarding the type and characteristics of the mineralization.

Field of Application for Applied Potential and Inductive Process

It would be futile at this stage of development of the art of geophysics to attempt to define arbitrarily the field of application for each of the various processes. It is doubtful if such a division can ever be made, because of the complexity of conditions usually encountered in actual field operations.

Comparative operating results under one set of conditions may be quite different from the results obtained under other conditions. The superiority of a process for some particular task can be judged only when due consideration is given the conditions under which the tests are conducted.

The applied potential methods offer by far the best solution for general geologic and tectonic investigations. These investigations include studies of folding (anticlines, synclines, faulting, and related data) and general subsurface investigations. Such processes are also particularly applicable to the location of conducting areas which have a large projection on the surface and which do not lie at too great depths. Conductors of small cross-section and sheet or vein conductors which do not outcrop are more difficult to locate by the applied potential methods.

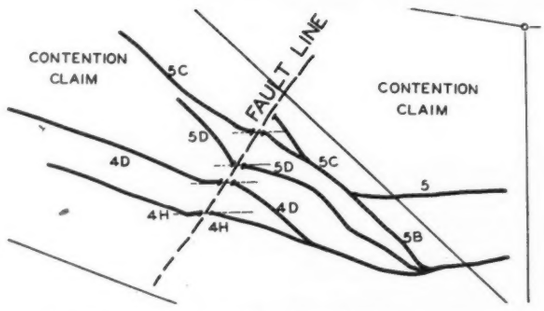
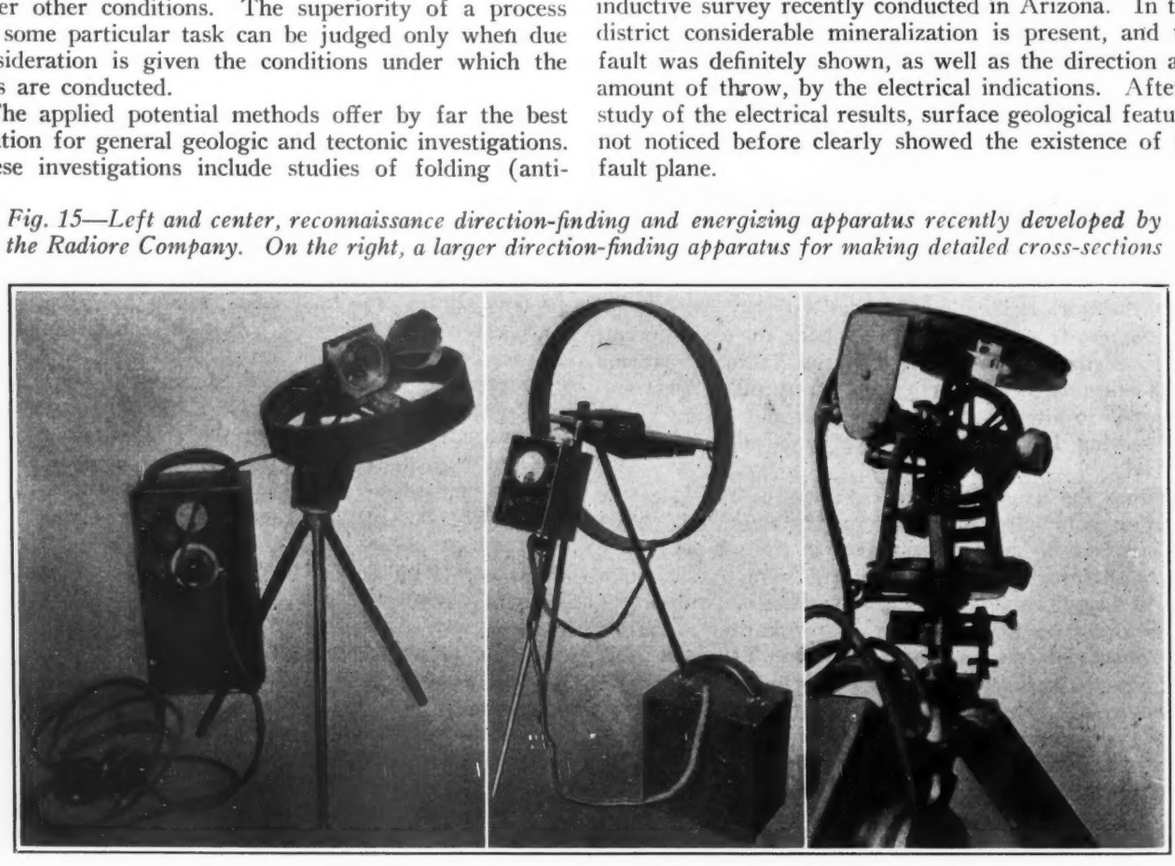


Fig. 16—An example of a fault line located by the inductive process

On the other hand, the inductive process operates very favorably on the small-diameter and sheet or vein conductors. Generally speaking, it can be said that the inductive process is not applicable unless mineralized areas are present which have a conductivity considerably greater than the surrounding earth. My experience leads me to believe that the applied potential processes, generally speaking, are of more value in tectonic and geological investigations, and that the inductive methods are of greater value in general mining and exploration work. A special case of the use of an inductive process in locating faults is shown in Fig. 16, which illustrates the results of an inductive survey recently conducted in Arizona. In this district considerable mineralization is present, and the fault was definitely shown, as well as the direction and amount of throw, by the electrical indications. After a study of the electrical results, surface geological features not noticed before clearly showed the existence of the fault plane.

Fig. 15—Left and center, reconnaissance direction-finding and energizing apparatus recently developed by the Radiore Company. On the right, a larger direction-finding apparatus for making detailed cross-sections



DISCUSSION

READERS of E.&M.J. are respectfully asked not to send in anonymous communications. Unless letters to the editor can be identified and their import, if there be any, made a matter of record, they will not be published. The writer's identity will be suppressed, if the request to do so be made, but the name and address of the correspondent must always be incorporated if he desires his comments to be read and published.

Common Sense and Invention in Fine Grinding and Screening

THE EDITOR:

Sir—Permit a vegetarian to say that he believes the article of Mr. Alfred James in your Dec. 24 issue is one of the meatiest in years. Mr. James mentions an instance where grinding 77 per cent through 200 mesh with one type of crushing was not as good as grinding 71 per cent through 200 with another type of crushing, because the latter had a larger amount ground to desirable intermediate sizes and less of the excessively fine and the excessively coarse. It is high time that the engineers who are not leaders woke up to the fact that the engineers who are leaders are getting completely away from the "finer the better" ideas in metallurgy.

Many engineers will still state that fine grinding is just what you want in oil flotation, when repeated instances indicate that moderately fine grinding has proved better than very fine grinding, and there are few if any instances in metallurgy where it would be desirable that all material should pass 200 mesh. In fact, if it were the general practice to grind all the material to a given mesh, 200-mesh grinding would almost cease in the entire metallurgical field, and finer than 200 mesh would increase in cement grinding.

We have had instances where ore ground through a disk pulverizer or through an end-discharge ball mill to 40 mesh gave poor results by flotation; and when ground to produce angular fragments, with as little undersize or slime as possible, gave high results.

Laboratory tests are reputed to give lower results on oil flotation than large-scale operation. I believe this is almost entirely due to the dry grinding in the laboratory tests. Wet grinding can be used in the Braun pulverizer, and it gives better results thus, because heat is generated where a fracture of the mineral occurs, and wet grinding prevents oxidation of that fractured surface. Grinding with the obviation of sliming improves results still more.

Bubbles attach themselves readily to flat surfaces of clean minerals, more readily to the edges of crystals, and still more readily to the corners of crystals, so that crushing to as uniform a size as possible must necessarily yield better results. One thing we do know about flotation is that it is a matter of surface. An objection to ordinary very fine grinding (or, more correctly, sliming) is that when colloidal material is produced there is a tendency to smear the surface of the particles one desires to float with the colloidal material; and a covered surface is a surface that will not aid in flotation. Clean, sharp angular grinding is desirable in flotation as well as in concentration. Colloids can be introduced to inhibit flotation of certain minerals, and large concerns are actually using this method.

In portland-cement grinding the aim is different. Little specific information is available on grinding below 200 mesh. It has often been stated that no successful screens have been made below 350 mesh "nor are they likely to be made." I cannot agree with the last statement and expect soon to exhibit some screens, originally 200 mesh, electroplated with chromium to any desirable sized opening, as fine as 600 mesh would be, or as much finer as is practicable. The statement was often made that lack of certain specific information, such as "How fine must portland cement be ground before it has hydraulic properties," was largely due to a lack of practical fine-mesh screens. United States government sources of information mention "a few pounds of 350 mesh laboriously screened by hand." Manufacturers were unable to answer the question of how fine the cement had to be.

My associates and myself screened portland cement so that we got a portion that passed completely through 200 mesh, and we tested the material between 200 and 300 mesh, and between 300 and 350 mesh. Neither of these sizes had any hydraulic properties. Here we have portland cement that passes 200 mesh, and some that passes 300 mesh with no hydraulic properties. This same material reground has excellent qualities. We believe that only a small percentage of portland cement has any hydraulic qualities. Nearly all cement manufacturers make specifications such as 80 per cent or 90 per cent through 200 mesh, and occasionally a "flour meter" is used. It may be that well over 1,000 mesh equivalent is required for hydraulic properties. We believe the value of portland cement depends not only on the surface exposed, but on the nature of that surface. It may be that there is also a low limit to the grinding for the proper hydraulic properties.

There is another curious fact, which does seem to be fairly well known in the cement industry. If "set" portland cement is ground enough to present new surfaces of the ground materials, this reground cement will set as firmly as the original, provided the regrinding has been carried far enough to produce new fractures instead of merely a breaking apart of old surfaces.

In the ceramic industry we have still other conditions. In some grinding, angular material is wanted. For other purposes very long particles are wanted and for still other purposes a variety of sizes to fill all cavities are wanted. For some filtration purposes uniform sizes with a maximum of voids is desired.

I believe there is one general rule, which will tell us

what grinding we wish in most cases. Where we wish to separate minerals, we should grind only moderately fine—that is, fine enough to separate mineral from gangue, and grind to make the material as granular and as uniform as possible. This covers practically all the metallurgical field. Where the problem is the combining of materials, as in the use of portland cement, grind very fine and use materials generally of differing sizes, although the different grindings should also be as uniform as possible, using different aggregates. This style of grinding covers nearly all the non-metallic field.

In speaking of anything finer than 350 mesh, only the opening as compared with that of a 200-mesh screen is meant. Thus by 1,000 mesh it is meant that the opening is one-fifth the diameter of a 200-mesh screen.

Los Angeles. JOHN HERMAN.

* * * *

Scope for Rubber in Metallurgy

THE EDITOR:

Sir—The editorial article, "Rubber in the Mining Industry," appearing in the Jan. 14, 1928, issue was read with much interest. It so happens that I have had some experience with several of the special rubber—or rubber-employing—appliances therein mentioned, during their earlier tryouts.

My particular interest, however, was perhaps most attracted by the reference to the use of perforated rubber as air-distributing blankets in pneumatic flotation cells. This would appear to be a rather promising possible field for the use of rubber—although by no means a really new one. While at the Hayden mill of the Ray Consolidated Copper Company (now a part of the Nevada Consolidated Copper Company) some ten years ago, I was personally instrumental in the conducting of some experiments with such perforated rubber flotation blankets of standard area. The blankets were furnished to us by the United States Rubber Company, through a member of that company's organization, Mr. Gordon Kyle. These thin rubber blankets were so perforated (by unthreaded sewing machine needles as I recall) that no rubber was actually removed—the idea being that the individual holes, which were spaced about one-quarter inch apart in each direction, would open sufficiently under a low air pressure to permit of proper pulp aëration, but would automatically close when the air pressure was removed and would then be practically impervious to the entrance of pulp.

For various reasons—perhaps chiefly because of the nearly flat cell bottoms with which these blankets were tried—the results were not then entirely satisfactory. For use with flotation bottoms of relatively steep slope—or under the still more favorable conditions as covers for the air distributing rotors of the MacIntosh flotation machines employed here in the Nacozari concentrator—perforated rubber blankets might well prove successful. With this in mind, about a year ago, I interested a representative of one of the large rubber manufacturing companies in endeavoring to produce a satisfactory perforated rubber blanket for such use—and just within the last three weeks we have received a blanket needle-punched at about one-quarter-inch centers. Some months ago, however, we began locally to manufacture perforated-rubber flotation blankets, using for this purpose some sheet rubber packing which happened to be on hand and available—though doubtless not so well suited for this purpose as certain other rubber sheets of different composition might be. Several of these blankets have since been placed in regular service as rotor covers of the MacIntosh flotation machines.

Various kinds of perforations and of punching have been tried, using locally made single or gang punches. In some cases, perforations have been used (usually at from one-fifth to one-half inch centers) from which no rubber has been removed; and in others, small but definite holes have been punched, with actual removal of rubber. These blankets have for the most part been used alone, although in some instances they have also been experimented with in connection with canvas porous media. Although it is yet too early to speak with finality, these experiments to date have given some very promising results, and they are being continued. We have also conducted some interesting experiments here with full-size flotation cells using, as the air distributing medium, a sheet, or drum, of thin metal perforated with a multiplicity of fine holes. Results have been promising.

The flotation blanket troubles ordinarily resulting from settling pyrite, or other heavy rejected ore constituents, from lime and similar depositions, have been so nearly eliminated here at the Nacozari concentrator, by the use of the MacIntosh cells, that our annoyances from such sources are comparatively small indeed. It is very possible, however, that either the perforated rubber blankets, or the perforated sheet metal, may prove to be of special worth when used as air distributing media in flotation machines treating pulps with which the usual canvas, or other fabric air distributing media, tends to become blinded by depositions resulting from the presence of unusual quantities of lime, or other deleterious salts.

WILLIAM T. MACDONALD,
Mill Superintendent.
Moctezuma Copper Company,
Nacozari, Sonora, Mexico.

* * * *

Railroad Grants and Mineral Lands

THE EDITOR:

Sir—I am writing this letter in order to get the opinion of others who are in the same predicament as that in which I found myself when I made a discovery of a mineral-bearing lode on Southern Pacific company lands in Siskiyou County, Calif. Undoubtedly there are many who will say that I had no business to be on patented railroad lands. True enough, if we care to acknowledge their rights and titles to these lands. As I understand it, the grant to the Southern Pacific by Congress provided that mineral lands should not be included in the grant. But I am in receipt of a letter from the Division Inspector, Department of the Interior, stating that this law has been construed by the courts to mean that the lands must have been known to be mineral in character at the time the railroad selected them. Consequently, if the railroad company has a patent to the lands in which you are interested, this patent could not be attached by the government unless it can be proven conclusively that the lands were known to be valuable for mineral at the time they were selected. If the lands were known to be mineral when the railroad selected them, and the grant to the Southern Pacific company by Congress provided mineral lands should not be included, how in the name of all sense did they get a title to these lands? Will some kind reader explain?

Ashland, Ore. E. J. KIESEL.

By the Way

Bandit Problem Solved

THE Chairman of the League to Preserve American Civilization looked up from his newspaper wherein he had been reading of the escape of Lyman F. Barber, mining engineer, from Mexican bandits. "I have always," he said, "been one to caution my fellow-countrymen about bandits. It is not unlikely that you have read my articles in the press, attended my meetings, heard me on the radio, confronted me in the *Congressional Record*. I opposed the appointment of Dwight Morrow because I felt he was too good a man to be risked. I objected to Lindbergh's flight because of my feeling. . . ."

The Chairman paused.

"I was wrong," he said. "They are harmless, unworthy of our fears. Or, if they ever were, we have developed a war instrument against them that will send them along the path trodden by the savage redskins. Did you notice what happened here? This man had one bottle of brandy. He divided it among four Mexican guards. That was—for we must assume the brandy was made, as usual, in the Bronx and was not an honest quart—about two-thirds of a gill per bandit. Each drank it, and each passed out."

The patriot again was thoughtful for a moment.

"My work is done," said he. "But, for the sake of our civilization, we must stand firmly against any interference with the Volstead act." —*N. Y. Times.*

* * * *

Abolishing the Smoke Farmer

EDITORIAL MENTION was recently made of the fact that the smoke farmer is still with us, and that the smelter must be on his guard against claims for damages from that source. Specifically, the new smelter at Rouyn, Quebec, was mentioned, the suggestion being made that the matter of fume damage in the surrounding territory should be considered. It seems, however, that some foresighted engineers or legislators thought of this matter some time ago, with the result that the following paragraphs appear in the Quebec Mining Act, as recently amended:

"No person shall prevent or hinder the operation of smelters, refineries, or other works for treating ores, constructed in Rouyn Township and adjacent townships, by means of an injunction or other legal proceedings. The recourse, if any, of a person prejudiced by such operations shall be confined to a claim for damages." And he apparently has small chance of being awarded a claim for damages in the light of the next paragraph, which reads:

"No owner, tenant, or occupant of land in the Township of Rouyn and adjacent townships, and no holder of a permit to cut timber in such townships, may claim damages on account of the harmful gases and smoke produced during the operation of a smelter, erected in the Township of Rouyn, on a site chosen or approved by the Lieutenant-Governor in Council; provided, however, that the plans and specifications for such smelter have been previously approved by the superintendent of mines. This provision shall apply to all lands already occupied, conceded, or patented in such townships as mining lands."

This makes it clear that the district is intended to be a mining district, and that if smelting activities interfere with agriculture, the farmer must make the best of it. Smelters in other parts of the world will no doubt look with envy on this legislation.

* * * *

Difficulties in Translation

A RECENT BULLETIN from Washington in an article translated from a Spanish magazine discusses briefly the difficulties of the Spanish lead producers. "It was suggested," the bulletin reads, "that the government ease the public money market so that advances may be available for the development of galleries and pits for investigation. . . . Almost all the lead foundries in Spain belong to foreign companies. . . . The mines owned by foreign companies are able to exist because they regain in transformations what is lost in exploitation." It strikes us that the translator is perhaps more familiar with coal mining, metal-casting plants, and hairdressing parlors than he is with mining and smelting lead.

Consultation

How Should Non-Metallic Mineral Claims Be Located?

"I have several lode claims located on a body of vermiculite and amphibole asbestos. I have been informed by a mining engineer that I could not hold non-metallic minerals with lode claims, and that the new United States law is that they must be located by placer claims. I immediately located placer claims over the lode claims, and inasmuch as I want to locate some more claims on this mineral, I would like your advice as to the proper way to do it—whether with lode or with placer claims.

"The same engineer, who has been working on non-metallic claims for years, told me that formerly he and his associates were accustomed to locate all their non-metallic claims as lode claims, but that since 1924 they have been locating them as placer and have even re-located the old lode claims as placer. He asserts that the U. S. Supreme Court has decided that a placer claim holds over a lode claim so far as non-metallic minerals are concerned."

Inquiry fails to reveal the existence of the legal decision referred to in the last paragraph. Possibly the inquirer is confused as to the court. It might be that the supreme court of some state rendered the decision instead of the U. S. Supreme Court.

The legal propositions entering into the question of locating non-metallic mineral claims may be stated as follows: Ordinarily the proper way to locate non-metallics is under the placer laws, but this cannot be stated as an absolute rule. The mineral involved is not the determining factor when deciding whether a claim should be located as a placer or as a lode claim. The proper method to be used depends entirely upon the formation of the mineral deposit, and it is not possible to advise how a claim should be located simply from knowledge of the kind of mineral involved. This is especially true of asbestos, which is a border-line substance and which sometimes should be located as a placer and sometimes as a lode, depending on the formation.

Limestone deposits are almost always located as placer claims. However, some time ago some one located such a deposit as a lode claim, and the Secretary of the Interior held that the lode claim was valid because of the peculiar nature of the deposit.

USEFUL OPERATING IDEAS

Skip Pockets for Inclined Shafts

By J. C. Pratt
Cerro de Pasco Copper Corporation, Casapalca, Peru

ALTHOUGH the pockets described in the following are designed and used in a shaft inclined at 70 deg. from the horizontal, they could be modified easily for use in a vertical shaft. The features they possess are economy in excavation and construction and ease and efficiency of operation.

As can be seen from the drawing, an inclined raise is run from the lower edge or corner of the sill of the measuring pocket. After the raise has been holed through to the level, the station for the pockets may be cut out and the pockets themselves constructed.

Pockets—The front of the main pockets is made of four upright 10x10-in. posts, to which the gates are fastened with lagscrews. The bottom is inclined at 45 deg. to insure free movement of the ore, which is sometimes wet. Both bottom and front are lined with 3x12-in. boards, covered with scrap plate.

The measuring pockets also have four 10x10-in. posts across their front. The capacity of those shown in the accompanying illustrations is only 39 cu.ft., suitable for a small skip. However, this could be increased as required. These pockets are also lined with 3x12-in. plank, covered with plates.

Gates—Arc gates with air cylinders are used on both main and measuring pockets and are of the same design for each. The bent lever arm may be noted, for when the gate is open the arm does not project beyond the line of opening, thus giving a free passage for the ore. A connecting rod is required because the gate works about a fixed shaft or axle, and the cylinder is stationary.

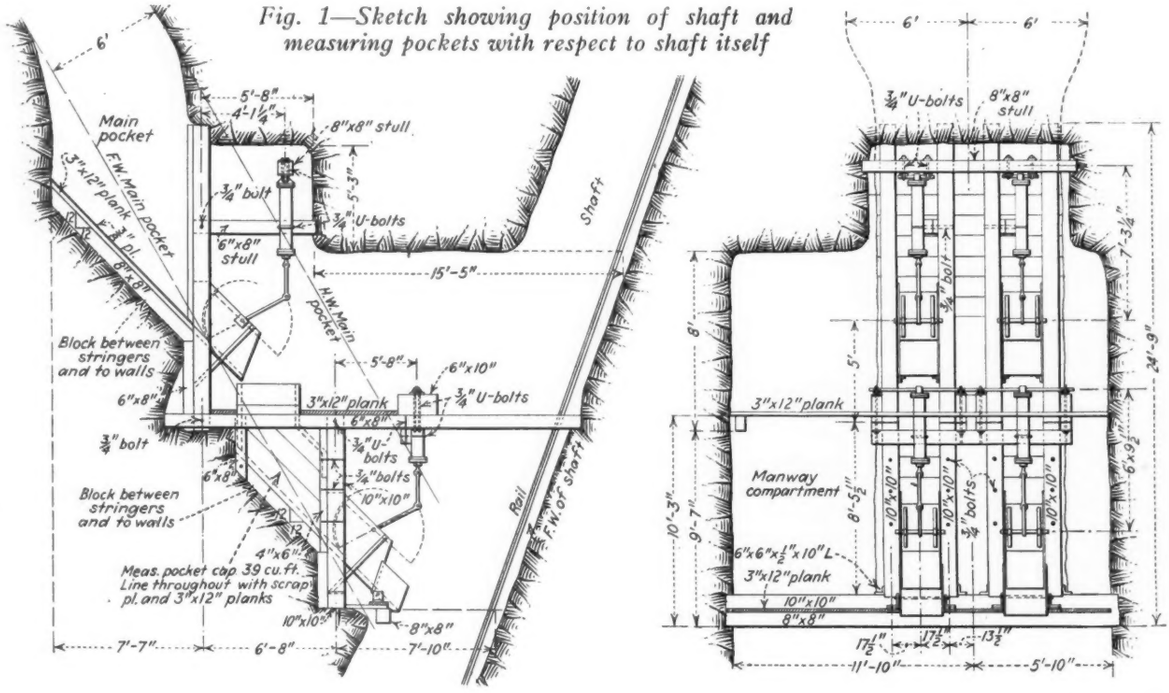
It is preferable to use a gate that rises from below in closing, to prevent large rocks from clogging it. However, with air cylinders of sufficient power no trouble should be had with the gates shown, especially if the ore passes through a grizzly as it is dumped from the cars.

Operation—The valves for all four gates are operated from the platform in front of the gates of the main pocket. Near them is placed the electric signal to the hoistman. The skip tender thus has everything within arm's reach. Only one man is needed to operate the pockets, and this he can do ordinarily without moving from his position. In two years of use the pockets have given satisfactory service at all times.

Protecting a Gyratory's Spider Legs

AFTER twenty months of operation it was noticed that the three legs of the lower spider on a primary crusher had worn considerably from the continued dropping of rock upon them, and if not checked the legs would eventually have been ruined, according to Louis Cassayre in a recent issue of *Rock Products*. The housing supporting and covering the inboard bearing of the drive shaft had been worn to such an extent that the bearing had been exposed and worn through to the shaft.

Fig. 1—Sketch showing position of shaft and measuring pockets with respect to shaft itself



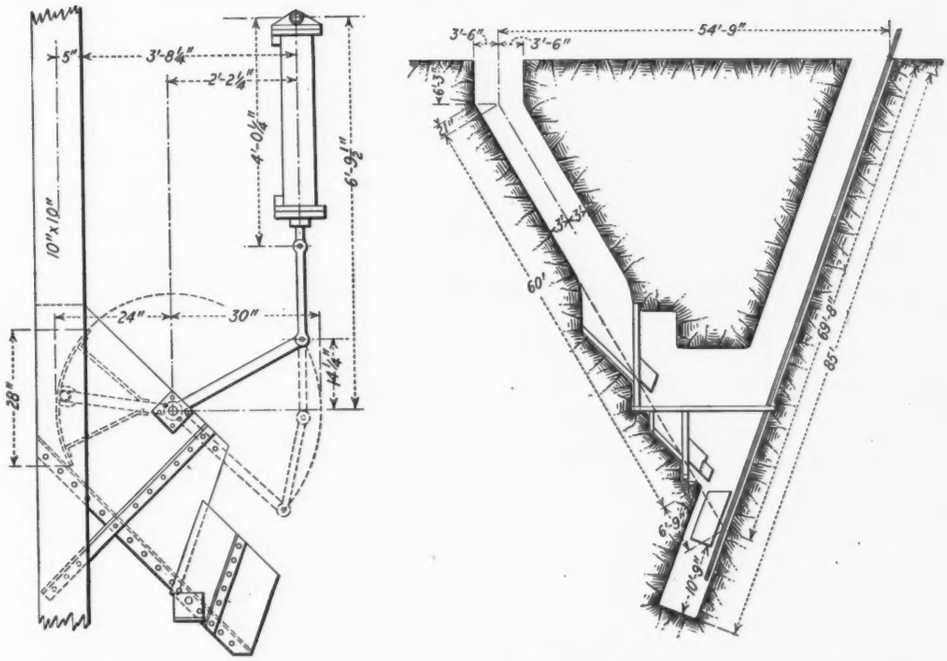
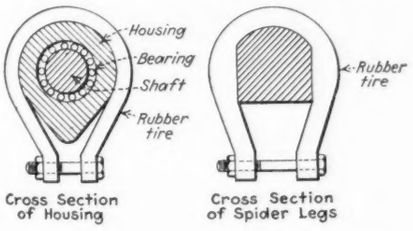


Fig. 2—Skip pockets, on 2,100 level, Carlos Francisco mine, Casapalca, Peru. See opposite page.

A thin sheet of iron was welded over the worn housing, the bearing was replaced, and a rubber tire was stretched over the housing and bolted loosely at the bottom. The spider legs were treated the same way. After eleven months of operation the tires were replaced. The spider legs and housing were found to be as good as ever.

This repair job was done at the plant of the Bassett Rock Company, Napa, Calif.



Protection for spider legs of gyratory crusher

Wire Cloth Useful Around the Plant

FOR the protection of belts and moving machine parts woven-wire guards are approved by all insurance companies and inspection bureaus. For making these guards, the Ludlow-Saylor Wire Company points out, wire cloth is easily cut and formed to proper sizes and shapes. It offers the least possible interference to the passage of light and air, and is easily applied to either wood or metal frames.

For tool rooms, factory partitions, storerooms, and countless other inclosures where the free passage of light and air is desired, wire cloth again affords an economical and permanent material. Bins for storage of parts or supplies are made cleaner and lighter by backing them up with wire cloth instead of solid partitioning.

The replacement of glass is a heavy expense in modern factory buildings. Wire cloth protection of skylights and windows eliminates this expense, besides removing the danger always present from tools or parts falling or being thrown from windows, papers blowing out, and similar occurrences.

Electrical Heat Permits Dry-House Economy

ELECTRIC HEAT for heating bath water for such of its employees as are at work on holidays or other days when most of the force is idle was recently adopted by an Illinois coal company. This method resulted in a substantial saving. Steam heating is still used for work days, when it provides for the needs of about 600 men. It requires about five tons of coal per day, and the services of three firemen for its operation. Because of the necessity for the employment of maintenance and construction men, this system had to be kept in readiness on idle days and holidays as well as on working days, and at no reduction in cost over the expense of operation on working days.

The initial electric heating installation now meets all the requirements for idle days and shutdown periods at a substantial decrease in operating cost. It is considered to be sufficient for 50 or more men, but is normally used by about 15. The water reaches bath temperature in three minutes after the current is turned on, and thereafter meets without delay all demands that conditions are likely to require.

Equipment consists of seven hot-and-cold showers. The water is heated in a 235-gal., heat-insulated, hot water tank by six 5,000-watt, 220-volt, helicoil sheath-wire immersion G.E. heating units. Heating is governed by complete thermostatic control, and the installation is so arranged that it will not interfere with steam operation.

It has been found that the cost of steam operation on either work days or idle periods is $34.25 per day, while that of electric heat, used on idle days, is only $7.64, which means a saving of $26.61. This is based on raising the temperature on 25 gal. of water for each of 15 men at a temperature of 60 deg. to 105 deg. F., at a rate of 1.3c. per kilowatt-hour for current by electrical operation. The expense of steam operation as given includes the cost of five tons of coal and the wages of three firemen.

INDUSTRIAL PROGRESS

The Present Status of Refractories in Power Plants

REFERENCES in the literature of the power plant field to the "boiler built around the furnace" in which no refractories are used has apparently caused apprehension among manufacturers of refractories as to the future status of the boiler furnace for their product, according to R. A. Sherman in a recent technical bulletin (No. 18) of the American Refractories Institute.

The remarkable advances made in recent years in reducing the cost of generating steam have resulted from (1) more efficient use of fuel; (2) use of lower grades of fuel; and (3) reduction of investment costs per unit of output. More efficient use of fuel has been made possible by improvements in the design and operation of equipment to obtain more efficient combustion and heat absorption; and reduction of investment costs has come about through operation of boilers at higher ratings, and decrease of charges due to repairs.

Although the improvements in fuel-burning equipment, boilers, and accessories have kept pace with the increased severity of service which results from more efficient combustion, higher ratings, and the use of lower grades of fuel, refractories have not, and the excessive cost of repairs and charges due to their failure often limits the efficiency and rating which could otherwise be obtained. Boiler and furnace are frequently no more reliable than the furnace lining.

When power-plant engineers found that the refractories commercially available would not withstand the extreme conditions of service they demanded improved refractories; these not forthcoming, they adopted methods to lessen the severity of conditions without decrease in efficiency. Air cooling was first tried, the air being used for combustion. It proved successful under moderate conditions but limited in application. The next development was the protection or replacement of the refractories in the most severely affected areas by water- or steam-cooled surfaces which formed part of the circulating system of the boiler. These were successful, and because the rate and efficiency of heat transfer to the water or steam are high, they have been extended to other parts of the furnace: in many furnaces refractories have been entirely eliminated.

Development and installation of the water-cooled furnace has progressed with increasing rapidity during the last three years. Water-cooled walls are evidently proving their worth, and their use will undoubtedly continue to increase in certain fields. However, the initial cost of water-cooled walls is generally greater than that of firebrick settings; their use is limited to those plants in which conditions of operation justify the increased investment necessary to secure high efficiencies and ratings. The field of water-cooled walls lies, therefore, among large central heating and electric-generating stations and certain large industrial power plants.

Small public-utility or industrial power plants generally have a low load factor and they therefore operate at low efficiencies because the investment in the equipment for higher efficiencies is not justified. There refractories service conditions ordinarily are not extremely severe, or even if they are the plant can often better afford to reduce the severity by operation at lower efficiencies than to make the investment necessary for water-cooled furnaces. A real demand exists, however, for better service from their refractories. The use of plastic refractories is increasing in these plants because of the lower cost of labor for their installation.

Between the extremes of the large and small power plants lie those plants of moderate size or of moderate severity of service, in many of which there may be an even choice between refractories and water-cooled furnaces. It may be taken for granted that the example set by the large plants in obtaining higher efficiencies and ratings will be followed as far as economically practicable and that the refractories will be called upon to stand more severe conditions than at present.

The Outlook

The future status of refractories in power plants largely depends, therefore, on the maintenance of their position in the plants of moderate size. Two principal lines of progress are open to the manufacturer of refractories: (1) Improvement of his product, and (2) proper application of his present product.

It has been stated, in regard to improvement of refractories, that study of base materials which offer possibilities for refractory products will show that pronounced advancement in development of these materials cannot be expected. However, little information is available on the minerals formed in the manufacture or in the service of a firebrick, and it is on the relative amounts of these minerals rather than on the chemical composition of the raw materials that the properties of refractories depend.

Use of special refractories made from other than fireclays is deterred by their high cost.

Proper Application of Present Product

Probably more hope for progress lies in the proper application of the present product. Definite knowledge of the capabilities and limitation of refractories has been hampered in the past by the lack of definite information on the conditions of service, and on the mechanism of failure of refractories.

During the last three and one-half years the U. S. Bureau of Mines, in co-operation with a special research committee of the American Society of Mechanical Engineers, has conducted a field investigation of refractories service conditions in boiler furnaces which has included the principal types of fuels and fuel-burning equipment. All factors which might be supposed to govern the life of refractories have been studied, and many data not previously available have been supplied to the ceramic engineer. Although the principal objective was to supply these facts to aid in study of the mechanism of failure, and it was but a means to an end, much of the information may be of immediate practical value to the manufacturer. The mechanism of failure is also being studied under the same co-operation by the U. S. Bureau of Standards and the University of Illinois.

This investigation is broader and more fundamental than any other phase of the refractories problem ever undertaken, and it affords manufacturers their best opportunity to obtain information necessary to advance their industry, for the application of the results is not confined to the boiler-furnace field.

The investigators have concluded that water-cooled walls for furnaces in those power plants in which the conditions of service exceed the inherent limitations of refractories should benefit rather than harm the refractories industry.

Manufacturers may now devote their attention to the improvement of their product and its proper application in those furnaces in which the conditions are suited to its use; and, to maintain their present position in that field, it appears to their interest to support an

active program of research. To regain business in that field where it has been lost they might well engage in the further development of water-cooled refractory walls. Walls of refractories cooled by water tubes to prevent their rapid failure combine the desirable features of high temperatures in the furnace and efficient, rapid heat absorption in the tubes. The ultimate in the design of this type of wall at low cost has surely not been reached.

Gun Sprays Bitumen

Applying liquid coatings by spraying has been carried into a new field, namely that of applying bituminous products as protective coatings to foundations, walls, pipe lines, dams, bridge piers and abutments and other structures. A gun has been devised for this purpose by the Quigley Furnace Specialties Company, 26 Cortlandt St., New York City. The new device is an adaptation of the refractory one previously developed by the same company for shooting plastic refractories or concrete mixtures in building or repairing furnace walls, baffles, concrete structures, stuccoing, and plastering.

The new gun consists of a cast-iron cylinder from which the bitumen is forced by a piston capable of high pressure. Atomization is obtained by a purely mechanical process and not by compressed air. Entrapping of air in the bituminous material is thus avoided.

To be able to handle bitumen, such a gun must be provided with a means for controlling the temperature. This is taken care of in the new device by a small self-contained kerosene burner. A thermometer having a large scale is also provided and placed where it is always in sight. Provision is also made for controlling the thickness of the coating. Penetration and adhesion, which are essential qualities in any bituminous coating, depend largely on the speed and heat of the spray. Both of these are under constant control in the new gun, so that perfect coverage is assured, according to the manufacturer.

After the gun has used up its charge of bitumen, compressed air is employed to send the piston back to its original position for reloading, which takes only a few minutes. The capacity of the gun is 15 gal., or enough to cover approximately 400 sq.ft. of surface. A long hose is used. Through it the bituminous material can be forced, the drop in temperature not exceeding 3 deg. for each 25 ft. of length.

A Fire Pump

Small mining communities are often without adequate fire-fighting facilities. Local requirements at the same time will not justify the purchase of an elaborate motorized pumper. For the purpose of serving this want, where it exists, a portable engine-driven rotary pumping unit has been introduced by Goulds Pumps, Inc. The pump has a capacity of 250 gal. per minute at a pressure of 100 lb. Engine and trailer are made by manufacturers prominent in their fields.

Flotation Machine Improved

THREE improvements have recently been made in the MacIntosh flotation machine. These are: Adoption of slip-over sock rotor coverings; adoption of Goodrich Cutless rubber bearings in the stuffing boxes; and all-metal construction of rotor.

The first has eliminated largely the difficulty previously experienced in applying the canvas to the rotor correctly, inasmuch as with the slip-over cover the tension on the canvas is the same over the entire area. This helps distribute the air better and has materially increased the life of the canvas. By the adoption of all-metal construction of the rotor it has been possible to eliminate all rope caulking and other bothersome methods of securing the canvas to the rotor.

More than 90 cells of this type have been placed in actual operation by more than 30 mining companies, in this country and abroad, since this machine was introduced a little more than one year ago. The operations cover flotation of lead, zinc, copper, and iron ores, and also sulphur.

With reference to this machine, it is interesting to note that the plant of the Moctezuma Copper Company, at Nacozari, was previously equipped with Callow cells, which were replaced with the MacIntosh machines with a resultant saving in air, according to the General Engineering Company, of Salt Lake City, which manufactures both machines. To furnish air for the Callow cells required two No. 7 blowers of the Roots type at 5 lb. pressure, and occasionally a No. 5½ blower in addition. The mill at present is equipped with 30 10-ft. MacIntosh cells, of which all but two are kept in operation. Air for the entire installation is now furnished by one No. 5½ Roots blower operated by 75-hp. motor.

"Mesh" vs. "Opening"

A clear distinction must be recognized between "mesh" and "opening" (or "space") before an intelligent specification for wire cloth can be written. "Mesh" is measured from center to center of wire—"opening" is the space in the clear between wires. The only absolutely accurate designation for the user of screens is the width of opening between wires, and the diameter of wire, both in decimal fractions of an inch. This point is emphasized by the Ludlow-Saylor Wire Company, of St. Louis, in a recent bulletin.

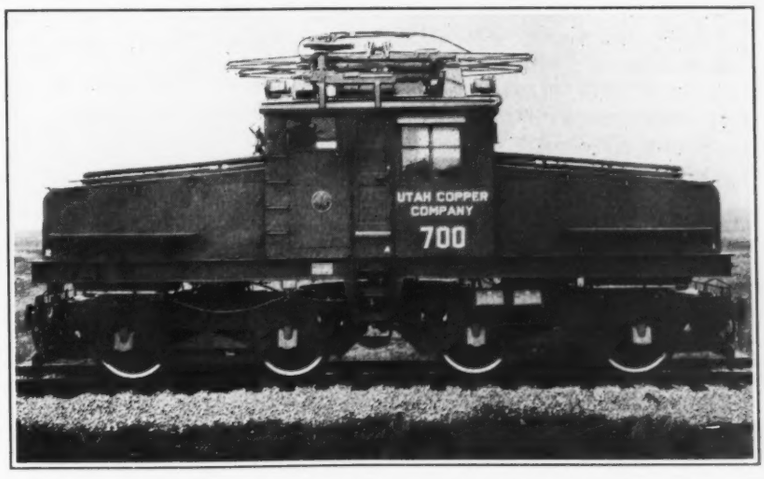
Locomotive Cable Reel in Unusual Position

ONE of the largest electric locomotives in mine service, placed in operation in the summer of 1927 by the Utah Copper Company at Bingham, Utah, is especially well equipped for operating under varied conditions. The locomotive is a 75-ton, combination storage battery and trolley type, and is used for serving electric shovels and for haulage on the various levels of the company's property.

In addition to the usual pantograph type of current collector, it is equipped with side-arm collectors, a motor-operated cable reel, and can be driven by power from its storage batteries. Where the usual overhead system of electric distribution is employed, the pantograph or side-arm collectors will be used, depending on the position of the trolley wire. Where no overhead wire is used, the locomotive can operate from the storage battery, or, by means of its cable reel, to a distance of approximately half a mile from the point of supply.

Instead of the usual practice of mounting the cable reel at one end of the locomotive, it is installed under the center of the locomotive, directly beneath the cab. An unusually large clearance is allowed between the truck framework and the body of the locomotive proper, thus making it easy to reach the motors for periodic inspection or maintenance.

A motor-generator set is installed in the cab for charging the storage battery while collecting power from trolley wires. Thus the time lost for battery charging is minimized.



The horizontal cable reel may be seen directly beneath the cab, over the trucks

NEWS OF THE WEEK

Summary

SENATE passes War Minerals Bill, sponsored by Senator Oddie, which provides for a final appeal to the Court of Claims in cases involving war minerals relief after the Secretary of the Interior has made his decision.

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Large deposits of potash are reported to have been discovered in Chihuahua. High prices for the mineral stimulate activity.

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Copper ore is discovered on Contact property near Bisbee, Ariz. Claim is under lease to four Arizona mining men.

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Western Australian government comes to the aid of Sons of Gwalia, Ltd., by loans totaling £78,000, to be used for new machinery and mine development.

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Flin Flon uncovers a second orebody to the south of main development at the 400 level. Crosscut shows 240 ft. of width.

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Colorado mining districts show signs of renewed activity. Several old mines are being reopened, including the Joe Dandy, in the Cripple Creek district, and new machinery is being installed at many plants.

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Tamarack attracts the attention of the Coeur d'Alene district by continuing development of large tonnages. Cedar Creek mill nears completion at Murray.

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North Butte bondholders may cause foreclosure. Stockholders claim that there is no need for bankruptcy proceedings, as assets overbalance liabilities.

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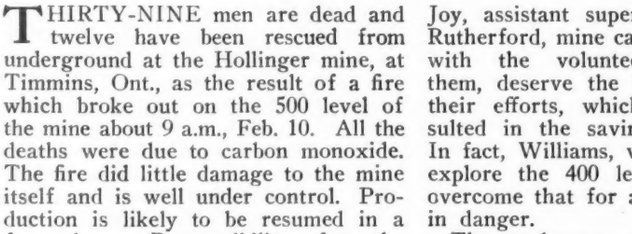
Ashanti Goldfields interests London financial circles again. Report of low assays checks speculation, but stockholders expect favorable developments as quartz is encountered.

Fire-Gas at Hollinger Kills 39

Blaze in Rubbish, Allowed to Accumulate in Abandoned Stope, Causes Worst Disaster in History of Canadian Metal Mining—U. S. Bureau of Mines Sends Rescue Car

THIRTY-NINE men are dead and twelve have been rescued from underground at the Hollinger mine, at Timmins, Ont., as the result of a fire which broke out on the 500 level of the mine about 9 a.m., Feb. 10. All the deaths were due to carbon monoxide. The fire did little damage to the mine itself and is well under control. Production is likely to be resumed in a few days. Responsibility for the disaster has not been ascertained. Officials have been energetic in normalizing the situation.



General view of Timmins, Ont.

Among the victims is Martin Stevens, shift boss, who lost his life in an attempt to warn the men and get them out of the mine. The fire started in an old stope between the 511 and 512 crosscuts near No. 11 shift in the eastern part of the property. In this stope refuse had apparently been accumulating for years. The fire, after burning fiercely for a time, died down, but smoke and poisonous gases were emitted in great volume. These rapidly spread through the mine. In fact, smoke rising from No. 11 shaft led to the report, later found incorrect, that the shaft timbers were on fire. The direct cause of the fire is unknown.

At the time that the fire broke out, between 800 and 900 men were underground, and an effort was immediately made to get them out. The great majority were reached, although some, who were in places where the smoke had not yet penetrated, refused at first to believe that there was trouble.

Rescue parties were immediately organized under the direction of Charles Williams, general superintendent; Victor Emory, mine superintendent; J. Doherty, production manager; Arthur Joy, assistant superintendent; and J. Rutherford, mine captain. These men, with the volunteers accompanying them, deserve the highest praise for their efforts, which undoubtedly resulted in the saving of many lives. In fact, Williams, while attempting to explore the 400 level, was so badly overcome that for a time his life was in danger.

The smoke was so dense and there was so much carbon monoxide gas that the work of rescue was extremely difficult and dangerous, as such rescue apparatus as was available was not suitable for the conditions met. By the evening of the tenth rescue work had to be abandoned, although every effort was made to penetrate the workings. An attempt was made to check the men off as they came out from underground, but many went home without reporting, so that it was difficult to tell how many were still below. It was believed, however, that there were between 50 and 60, mostly on the 500 and 600 levels. The fire itself was not believed to be serious and the air and water lines were intact. The compressors were kept running in the hope that at least some of the men still below would be able to reach dead ends with a plentiful supply of fresh air.

An attempt had been made to locate smoke helmets. It was found that the nearest were in Toronto. The Toronto Fire Department was able to spare four and the Consumers Gas Company three. Arrangements were made to dispatch these to the mine in charge of experts, Lieutenant Moody, of the fire department, and J. Brooks, of the gas company. These men, with this equipment and other rescue apparatus,

accompanied by T. F. Sutherland, chief inspector of mines, left Toronto by special train 8:30 p.m. on Feb. 10. This special was given precedence over all traffic and made a run never before equaled on this line, reaching Timmins at 9:30 on the morning of the eleventh about seven hours faster than the ordinary running time.

Surface view of the Hollinger mine

On arrival of the train from Toronto the rescue work was again started, and the parties were able to find many men who had taken refuge in a crosscut to which air lines had been laid. Seven of these men were brought to the surface, most of whom appeared to be in good condition, but as a precautionary measure they were all taken to the hospital. Five more were known to be alive in a crosscut on the 400 level, as George Zoleb, who was with them, managed to crawl out and give the word. Five bodies were found on the No. 8 level, two in a stope and three in a crosscut. It was hoped that many of those unaccounted for had been able to find a safe place of refuge and that the death list might not be as large as was originally feared. Rescue work was continued throughout the day, but on the evening of the eleventh again had to be abandoned as the range of the apparatus was too limited for the extensive workings.

President Timmins and General Manager Brigham, who were in Montreal, were able, through the courtesy of the U. S. Bureau of Mines, to obtain a mine rescue car from the Pittsburgh station. This car left Pittsburgh running special on the morning of the eleventh, left Toronto at 6:30 the same evening, and arrived in Timmins at 6:30 on the morning of the twelfth, after a journey of 855 miles.

Further work of rescue had been delayed until the arrival of the Pittsburgh car. Immediately upon its arrival, on the morning of the twelfth, this apparatus was put into use and search parties spent the morning in the mine without finding any more living men, although several bodies were still underground; Every effort was concentrated on trying to save the missing. It was believed that the majority of those men were on the other side of the fire, and it was decided that the first thing to try to do was to put the fire out.

The prompt action of the U. S. Bureau of Mines in sending the rescue car has earned the thanks and gratitude of the entire country.

The Hollinger mine is connected with the McIntyre by a small opening, and as smoke and gas were entering the McIntyre the men were withdrawn as a precautionary measure. On the afternoon of the eleventh the Hollinger fan was started exhausting, and by the morning of the twelfth the smoke had appreciably lessened in the underground workings.

A thorough government investigation into the cause of the fire will be instigated. It is rumored that officials received a warning regarding the condition of the stopes not more than three weeks before the disaster took place. Now that the last body has been recovered, the jury for the coroner's inquest will be empaneled. It is probable that this jury will consist entirely of mining men, for it is felt that, in a case of this importance, men with at least a working knowledge of conditions in a mine should sit in judgment. Public opinion throughout the district has been thoroughly aroused and it demands a full explanation of the causes, and, if possible, the fixing of responsibility. This demand has perhaps been made more insistent by the fact that the company has been very reticent about bringing the facts to light.

The Hollinger is the largest gold mine on the continent of America. It employs about 2,500 men, has fully 75 miles of workings, and accounts for almost half of Ontario's gold production. This is the first case of fire in an Ontario mine in which lives have been lost, and the extent of the disaster may have far-reaching effects.

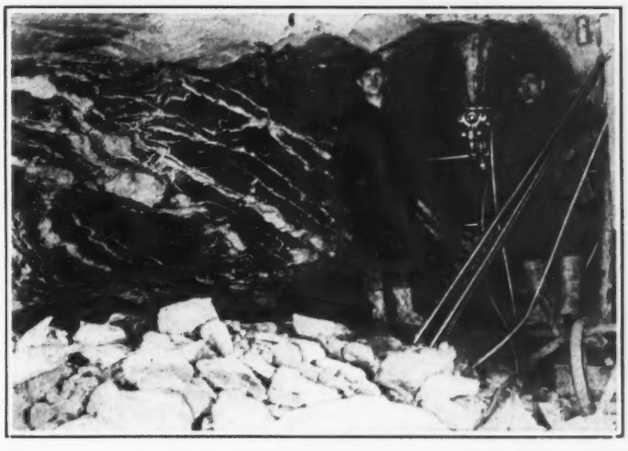
Texas Quicksilver District Plans Development

INTEREST in the Terlingua quicksilver district of Texas continues active. To date the development of the region has been retarded by the lack of transportation. The nearest railway is about 80 miles away. Recently, however, announcement has been made of a proposed extension of the Kansas City, Mexico & Orient Railroad from Alpine to Presidio. This would reduce the distance to 35 miles.

The Chisos Mining Company has been a steady producer for some time, but some other companies, notably the Study Butte, are preparing for production. Study Butte was active in 1920, but has been idle since. E. A. Waldron, owner of the Waldron mine, which has been producing cinnabar ore in good quantities for more than a year, is having surveys made of other claims which he may develop. Work has been going on at the Thirty mine, as it is called, and a furnace will be installed soon.

Australian Tariff Board Against Copper Bounty

After an investigation into a request by Australian copper-mining interests for the payment of a bounty on the local production of copper, the Commonwealth Tariff Board, in a report to the Minister of Customs, has recommended that the requests for a bounty should not be granted.



Underground at the Hollinger

C.F. & I. Investigates Iron-Ore Beneficiation

The Colorado Fuel & Iron Company is conducting an intensive investigation into the problem of concentrating the lower-grade iron ores from its Sunrise properties in Wyoming. The Colorado State experimental plant at Golden has been used for this work, and a number of men have been employed in this investigation for several months.

It is reported that a satisfactory method of gravity concentration has been worked out by the company, involving jigs and tables.

Magna Gold Mines to Erect 10-Ton Pilot Mill

Building of a new camp for the accommodation of 25 men and installation of surface equipment, including a hoist and compressor, at the property of the Magna Gold Mines Company, in Landa County, Nev., 42 miles southwest of Austin, has been followed by the purchasing of a 10-ton pilot mill. Tests of the considerable tonnage of gold ore opened up will be made by Thomas Varley, formerly superintendent of the Salt Lake station of the U. S. Bureau of Mines.

Senate Passes Oddie War Minerals Bill Providing for Appeal to Court of Claims

By Paul Wooton
Special Washington Correspondent

SENATOR Oddie's bill providing for the liberalization of the War Minerals Relief Act has been passed by the Senate. The bill amends the act by striking out the provision that the decisions of the Secretary of the Interior in War Minerals Relief cases are to be conclusive and final and also repeals that portion of the act which provides "that nothing in the act shall be construed to confer jurisdiction upon any court to entertain a suit against the United States." Under the Oddie bill, which the Senate just has approved, the procedure in the future would be as follows:

"In cases where final decisions of the Secretary of the Interior have been heretofore rendered, appeal to the Court of Claims shall be made within 90 days after the passage of this act; and in all cases where final decisions of the Secretary of the Interior have not heretofore been rendered, appeals from such decisions to the Court of Claims shall be made within 90 days after such decisions shall have been rendered by said Secretary: Provided, That no acceptance or acquittance by any claimant of or for any settlement made heretofore by the said Secretary shall prevent or estop any appeal to the said Court of Claims, as herein provided for."

A similar bill was passed by the Senate in two preceding Congresses, but the measure heretofore has failed to meet the approval of the House of Representatives.

Members of the Senate Committee on Mines and Mining are scheduled to hold a session of the committee on Feb. 16. A round-table discussion of the problem presented by the failure of Congress and the executive departments to support the general demand in the West for more active co-operation will be held. Director Turner, of the U. S. Bureau of Mines, and Director George Otis Smith, of the U. S. Geological Survey, have been requested to meet with the committee. In addition, it is expected that the committee will discuss the effort to secure a supplemental estimate for the funds needed to expand the experiment work at the Bureau of Mines stations.

Potash in Texas

The Bureau of Mines completed its No. 6 potash well at a depth of 1,436 ft., where the drill ran through the salt bed. The full core was recovered. As soon as the casing can be pulled the drilling equipment will be moved to the No. 7 location on the Roxana-Hughes lease in Upton County, Tex., where the salt formation is found at a depth of 450 ft. A churn drill will be used to penetrate the overburden, but a core will be taken of the potash deposit which has a thickness of 2,600 ft. at that location.

New Orebody Is Discovered at Flin Flon

A NEW orebody of substantial size has been found at the Flin Flon mine south of the main orebody. At the 400 level a crosscut shows 240 ft. in width averaging 2 per cent copper and some zinc. Included in this width, however, are some sections of much higher grade, one of 28-ft. width running between 5 and 6 per cent copper. The body has already been drifted on for a length of approximately 300 ft. Sites for the concentrator and the smelter have been chosen. A new townsite is being developed, as the present camp buildings will have to be torn down to make room for the new plant. At present 200 men are employed, but this number is being increased. Good progress is being made in constructing the railway, as the country offers few difficulties, and about 20 miles of rail have been laid. No ballasting has yet been done.

Preparations are being made for active development work on the Callinan Flin Flon property. Camp buildings to accommodate a crew of 50 men have been provided. A mining plant and two diamond drills are being sent in. It is proposed to sink a shaft to a depth of 500 ft. About 40 ft. of ore has been indicated by diamond drilling.

Tamarack Cuts Oreshoot on No. 5 Tunnel

WITH the opening of 80 ft. of good ore, the Tamarack mine is attracting the attention of the Coeur d'Alene district. The oreshoot which was discovered a few months ago on the 600 level, and which was again encountered at the 400 level, was cut recently on the No. 5 tunnel level. This work is proceeding from the Canyon side of the mountain. Crosscutting for the same orebody is being carried out from the Nine Mile side.

It is hoped that as a consequence of these developments, a sufficiently large body of ore will be made available to keep the company's big mill in operation for many years. Shipments already made have increased the company's output to a greater amount than it has been at any time during the preceding year.

Announcement is made that the 100-ton mill being constructed for Cedar Creek Mining & Development near Murray, Idaho, is nearing completion. The plant is to be equipped for the separation of lead and zinc by flotation.

At the same time, plans are being drawn up for another mill in the Coeur d'Alene district. Golconda Lead is erecting a selective flotation plant, equipped with all the newest devices. It is to be of 200 tons' capacity. In the meanwhile, operations at the mine are proceeding satisfactorily. Faces are in ore on all the levels.

A new 25-hp. hoist was recently installed at the Constitution mine at Kellogg. It takes the place of one destroyed by fire a few weeks ago.

Classic Flotation Litigation Decision Handed Down

AFTER a silence of four and one-half years—long enough to put ideas into the head of even a Washington Irving—Justice Peters of the United States District Court of Maine emerged from his chamber and handed down a decision in the classic Minerals Separation-Magma Copper Company flotation litigation. No explanation for the long silence was offered.

The decision upholds the validity of Minerals Separation's "soluble frothing agent" patent, the second basic patent of that organization, which expired in June, 1927. The case was tried during late June and early July in 1923, and the long silence is indeed difficult to explain. The decision is not considered of great importance, although it rules that the Minerals Separation Corporation patent was infringed by pneumatic agitation in the Callow flotation sell. An accounting has been ordered by the court, to determine the amount of damage to be assessed against Magma Copper. It is claimed by Minerals Separation that all but one other user of pneumatic flotation has been paying royalty pending the decision.

Three Men Killed at Plant of Inspiration Copper

THREE Mexicans, Reyes Barba, Raymundo Rubalcava, and Romolo Herera, were killed at Inspiration's leaching plant, Inspiration, Ariz., on Feb. 7. They were on the night shift and, early in the morning, just before the end of the shift, they had gone into the tunnel in which the conveyor belt runs which carries the crushed ore away from the $\frac{3}{8}$-in. rolls.

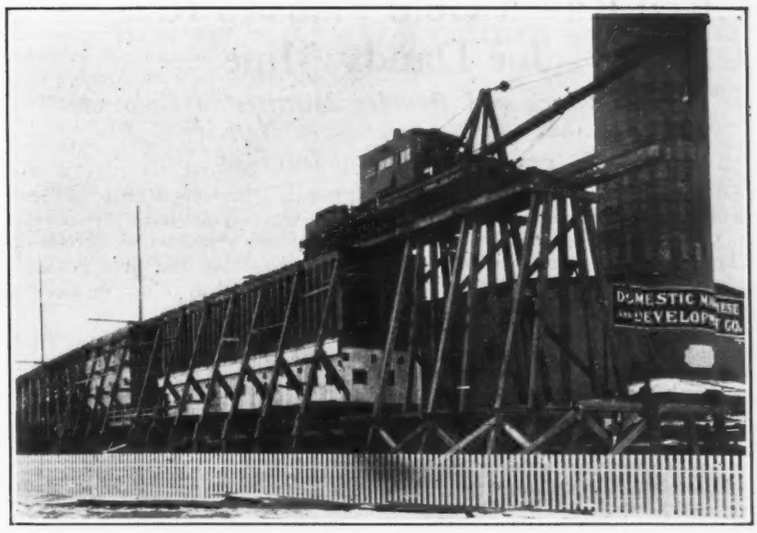
In operation, the ore after passing through the rolls is discharged into a bin from which it passes to the belt through a chute, the lip of which is from 6 to 8 in. above the belt. The latter was not in motion and the men had lain down on it and gone to sleep. Soon afterward, the shift foreman started the belt in order to remove a piece of steel which had passed the rolls and fallen through the chute. The control for the belt-drive is on surface above the tunnel so the foreman did not see the men until they had been dragged under the chute-lip and their bodies carried outside on the belt.

From the information and evidence at hand, the men had been almost instantly killed.

Manganese Plant at Butte Nears Completion

THE illustration at the right shows the new plant of the Domestic Manganese & Development Company, installed in the old Butte Reduction Works at Butte, Mont., which is to start operations within the next few weeks. The lower part of the old stack is seen at the right, and the new unloading trestle and ore bins are in the foreground. The trestle, which connects with the Chicago, Milwaukee, St. Paul & Pacific Ry., was built at a cost of $70,000. Rhodochrosite —locally known as pink manganese ore —will be roasted at the new plant. In this operation carbon dioxide will be expelled, and the grade of manganese raised to over 50 per cent. Later magnetic machinery will be installed to concentrate the lower-grade "pink ore" before roasting.

When completed the plant will consist of four roasting units, each unit comprising a rotary kiln 8 ft. in diameter and 125 ft. long and a cooler 5 ft. wide and 50 ft. in length. The spur from the main line of the railroad to the north and south sides of the plant is approximately one-fourth of a mile in length, and has two branches, known as the low and high lines. The latter, starting at a point just over Silver Bow Creek, gradually rises from the roadbed to an elevation of 45 ft. above the ground on the south side of the building, in order that the crude ore can be efficiently handled from the cars into the ore bins under the trestle, and thence through the feeder to the kiln. After the ore has been sintered and dropped down through the coolers, it is automatically loaded aboard the cars on the north side of the plant and is then ready for shipment to Eastern consumers.



Plant of the Domestic Manganese & Development Company

There are two other manganese mills in the state, both being situated near Philipsburg. One is controlled by the Hickey interests and the other by the Trout Mining Company. These plants are magnetically concentrating black manganese ore, and not rhodochrosite, as erroneously stated in the Dec. 24, 1927, issue of *Engineering and Mining Journal.*

Sons of Gwalia Is Aided by Government

IT IS stated that the Western Australian government has come to the aid of the Sons of Gwalia, Ltd., by offering to advance sums totaling £38,000 for machinery and £40,000 for mine development. This money will be advanced as required during the next three or four years, at 6½ per cent interest.

The Sons of Gwalia properties, near Gwalia, constitute one of the most promising "out-back" mines in Western Australia. More than 300 men are employed by the company. In 1923 a new stamp mill was installed, replacing the plant destroyed by fire some years before. Although the mine and plant have been operated efficiently, results have not been satisfactory to the shareholders. This made impossible any efforts to raise additional capital for necessary mine development and additional equipment. In fact, for a time, it was thought that it might be necessary to close down. Fortunately, the government chose this most propitious moment for making its offer.

Anaconda Wins Flotation Patent Suit

Anaconda has won a decision in the suit of the Metals Recovery Company against the Anaconda Copper Mining Company. The plaintiffs alleged infringement of flotation patents, stating that the Minerals Separation process being used by Anaconda is an infringement of plaintiff's patents. Trial was held at Helena, Mont. W. N. Davis and M. W. Sage, of New York, and E. B. Howell, of Butte, were the attorneys for the plaintiff, while L. O. Evans, chief of legal staff of the Anaconda company, Butte, and Chas. Neave and John F. Neary, of New York, represented the defendant. Witnesses for the defense were B. S. Morrow, concentration superintendent at the Washoe plant, Thomas A. Janney, Andrew Clausen and R. B. Martin of the Utah Copper Company, E. Shores of the American Smelting & Refining Company, and William H. Walker, consulting engineer of Pasadena, Calif.

High-Grade Gold Ore in New South Wales

IN A REPORT on the recently discovered gold find at Sugarloaf Mountain, near Nethercote, in the southeast of New South Wales, the district inspector of mines states that the discovery is in rough country well supplied with timber. Dickie and McLeod, prospectors, have applied for a lease of twelve acres. About 35 cwt. of ore, taken out by the prospectors and treated at the Port Kembla smelting works, gave a net return of over £270. This means about 40 oz. of gold to the ton. Samples taken by the inspector over a width of 2 ft. near the bottom of the 20-ft. shaft, from the surface of which the ore is said to have been obtained, gave a return of 5 oz. 3 dwt. 10 grains.

Another Copper Vein Found in Bisbee District

A DISCOVERY of copper ore has been made on the Contact lease near Don Luis, south of Bisbee, Ariz. Discovery of the ore was made on property which was leased by the Copper Queen branch of the Phelps Dodge Corporation to four Arizona mining men under a longer term contract than is usually given. The strike of the vein crosses the Duffy homestead, over which there had been much litigation in the last few years, and the Copper Queen Extension property. The latter is owned by John J. Higgins. Samples assay from 10 to 12 per cent copper in the oxide form.

Plans for moving the Upper Lowell section of the main line tracks which connect the Sacramento shaft and pit with the concentrator southwest of Warren have been announced by the Copper Queen branch. It was found necessary to make the change because of the constant settling of the ground.

High-grade chalcocite ore has been discovered on the 2,000 level of the Denn mine, at Lowell, Ariz. The face of the No. 2 crosscut is entirely in ore, and is said to assay 30 per cent copper. Further exploration will be necessary before the length of the vein can be determined definitely.

The Sheldon Mining Company has let a contract for deepening the 3-compartment No. 2 shaft on its copper-lead property at Walker, Ariz., to E. J. Longyear Company of Minneapolis. The shaft will be sunk 400 ft. from its present depth of 880 ft.

Red Raven Gold Plans to Reopen Joe Dandy Mine

Cripple Creek and Boulder Districts in Colorado Show Signs of Renewed Activity —New Equipment Installed

REOPENING of the Joe Dandy mine on Raven Hill, near Cripple Creek, Colo., is planned by Red Raven Gold Mining, which holds the property under bond and lease. During the last month, the company has purchased an electric compressor and a hoist, with motors. The machinery has been hauled to the mine for installation. The Joe Dandy was formerly operated by steam power. According to plans, all equipment is to be electrical hereafter. The main shaft of the mine is nearly 800 ft. deep. Laterals connect it with the Blue Flag on the north and with the Moose and Cresson on the south. Bond and leases on several adjoining claims have also been secured by the Red Raven. These properties, together with the Joe Dandy, give the company a total of 40 acres of mining land. It is said that the old workings will be thrown open to sublease, as the company prefers to devote its attention to new territory.

Production of 125 tons of ore a week has been established by the Blue Bird property of Silver Lead Metals. This production will be maintained in addition to development work. Last week's output amounted to 150 tons, bringing the mine's total for the month up to 500 tons. Development work will be limited to the remaining capacity of the mine. For the accommodation of more leasers, a larger motor to supply power for repair and compressor facilities will be installed.

Fanny Fern Mining has taken over the Index mine, in the Cripple Creek district, under bond and lease. This mine, too, has been equipped completely with electrical machinery. Work is progressing on the main shaft, which needed repair. A campaign of development in the lower levels will follow. This work, if it fulfills expectations, should bring the mine to a producing basis within a month. Good values are exposed at a number of points. Sublessees will begin work immediately.

Another old property to be brought back to production is the Caribou mine, of American Mines & Smelting. Recent exploration on the property, which was dormant for a number of years, has disclosed a vein on the 1,040 level. It measures 2 ft. in width, and has been developed for 14 ft. The vein assays average 15 per cent lead, 88 oz. copper, and 0.70 oz. gold to the ton.

Changes are being made in the mill of the Royal Tiger Mines, at Breckenridge, Colo., to enable the saving of free gold values separately. Oscar N. Bribach, selective flotation expert, who recently supervised changes in the American Metal plant at Glorieta, N. M., is in charge. The Royal Tiger mill is of 50 tons' capacity.

A six-cell flotation machine of the latest type has just been installed at the mill of the Fairview Mining at Cardinal, Colo. Operations have been resumed after a short shutdown to permit installation. Plans of the management call for the installation of one or more additional machines.

Another Breckenridge mine, the Gold Dust, is being unwatered preparatory to further development by New Washington Mines. Gold Dust is located on Nigger Hill.

Hudson Bay M. & S. Elects Officers

The Hudson Bay Mining & Smelting Company, recently organized by the Whitney interests to take over their Flin Flon holdings, has announced the names of its officials and directors. Frank L. Croker is president of the company; Henry Krumb, vice-president; Arthur H. Lockett, vice-president; Henry E. Dodge, secretary-treasurer; H. E. Franklin, assistant treasurer; William T. Smith, assistant secretary; and Carroll Searls, assistant vice-president. The directors are Charles F. Ayer, R. H. Channing, Jr., Frank L. Croker, Henry Krumb, Arthur H. Lockett, Vernon Munroe, Britton Osler, James Watson, and Cornelius V. Whitney.

Above—Granite Mountain shaft of the North Butte Mining Company. Below—Main Range shaft

North Butte Bondholders May Cause Foreclosure

PAM & HURD, Chicago attorneys, representing bondholders of the North Butte Mining Company, have asked that the stockholders' action to remove receivership be postponed for twenty days, in order that they may start foreclosure proceedings and sell the property. It is stated that the bondholders represented by the attorney in turn represent the same interests that recently put the company into receivership. Local stockholders claim there was no call for receivership, as the company has over $8,500,000 of assets and only $600,000 of liabilities.

The North Butte Mining Company was formed in 1905 to develop and operate the Speculator property and contiguous ground. Production at first was phenomenal, but gradually the ore became of lower copper tenor as operations increased in depth. It became necessary to enlarge the scale of mining operations, and to this end the Granite Mountain shaft was sunk to a depth of 3,700 ft. Economic conditions became so difficult by 1923, however, that all work was suspended. In 1926 the company acquired and merged the Tuolumne Copper Company, through the Main Range shaft of which it was possible to work the Sarsfield group. An improved condition in the company's operations was expected to result from the merger, but in June of the following year the company was thrown into receivership by a group of the stockholders.

The Granite Mountain and Main Range shafts are shown above.

Mexico City Letter

By W. L. Vail
Special Correspondent

Potash Found in Chihuahua—Air Mail Interests Mine Owners

Mexico City, Feb. 1, 1928—The return of American Ambassador Morrow from Havana has revived hopes of an early settlement of the problems that involve the United States and Mexico at present. There is perhaps more optimism now than at any time for the last few years, based largely on confidence in the ability of the Ambassador.

Some large deposits of potash have been discovered on the Palomas properties, in Chihuahua, owned by Americans, which are now being developed. The owners are working on a process to convert the potash from its present insoluble state. They hope to make it commercially profitable in competition with German fertilizers, which are imported into the United States in large quantities. High prices in the United States last year and large consumption are stimulating activity here.

Air-mail service is being sought by a number of interior mining camps. It has already been established at the Hearst properties in the State of Durango, making connection with the San Dimas camp. Requests for concessions in the States of Chiapas and Guerrero are also on file in the Department of Communications.

LOCAL papers state that the federal government has agreed to make a considerable reduction in certain taxes and duties for the purpose of enabling the Cananea and Moctezuma Copper companies, of Sonora, to begin active and intensive work on some of the recently discovered copper veins. Otherwise it would have been necessary to close a considerable part of the works until metal prices were better. It is also stated that the same advantages will be extended to other copper camps which may find themselves in a similar condition. The stand of the government is taken to mean an active revival of copper mining, particularly in the State of Sonora.

Such reports of mine operations throughout Mexico as have been received to date show a slight increase in production for the principal minerals during the first two months of this year, over the last two months of 1927. A number of new plants have been installed in various sections of the country. Applications for mining concessions both for exploration and exploitation have also exceeded those for the same period last year.

Directors of the Coloso Mining Company, district of Pachuca, at the annual meeting, unanimously recommended liquidation of the company, since it is impossible to secure funds for further exploitation. It had been hoped that a neighboring mining company would enter into a contract for development and exploration work on a share basis, but this hope proved futile.

Completion of a road to its properties by the Productos Quimicos company, Zacatecas, is announced. A percolating tank was built at the same time. A precipitation plant, ovens, and roadways for transporting the pyrites to the plant are now under construction. The management expects to start active production within a few months.

Toronto Letter

By Our Special Correspondent for Northern Ontario

Towagmac and Laval-Quebec Option Properties in Sudbury District

Toronto, Feb. 4, 1928.—Directors of the Laval-Quebec Mines, Ltd., have announced to the shareholders that the company has taken an option on the Serpent Basin Mines, Ltd. The option covers a period of six years on a schedule of payments, shares in the Serpent Basin being received for money expended. The property is about 60 miles west of Sudbury. Geology and structure are similar to Sudbury, and surface sampling shows fair values in copper. A subsidiary company has been formed called the Serpent Basin Mines, with a capital of 5,000,000 shares of $1 par. The Laval-Quebec has an option on 3,000,000 shares. All of the sellers' shares are to be pooled for a period of three years.

Diamond drilling on the Collins-Babson property, located in Geneva Township, in the Sudbury district, has been going on for some time. An official announcement has been made that the Towagmac Exploration Company will exercise its option on the property, as 2,000 ft. of diamond drilling has indicated from a million to one and a half million dollars' worth of high grade lead-zinc ore carrying fair values in precious metals. Under the terms of the option, Towagmac does not have to make any cash payment, but must equip the mine and bring it to a production of 50 tons a day within a period of two years. In return for this outlay, which is estimated at not more than $150,000, Towagmac will receive 70 per cent of the capital stock of a company now being incorporated under the name of Collins Mining Company, Ltd. A complete mining plant has been ordered, and development of the property will be under way within a month. At the Aldermac property, in which the Towagmac holds a substantial interest, development work on the 250 and 500 levels is rapidly delimiting the orebody. It is believed to be the largest single orebody in the Rouyn district.

London Letter

By W. A. Doman
Special Correspondent

Ashanti Goldfields Report Checks Speculators and Lowers Price

London, Jan. 31, 1928.—Ashanti Goldfields published a report at the end of last week, and it failed to give satisfaction to the market. Existence of great widths of reef and high gold content had so raised hopes that the announcement of broken ground with low assays proved a disappointment. The inevitable happened, and the shares fell several shillings when speculators in the stock, of whom there are many, thought it advisable to secure profits. If they had read the report carefully, however, they would have noticed that when the broken ground had been traversed, a face of solid quartz was encountered. Shareholders are now anxiously awaiting the result of testing. From the trend of the two reefs as indicated by a rough sketch it would appear that they are junctioning.

It is announced that the Southern Rhodesia Base Metals Corporation has ceased operations at the Copper Queen, where large amounts of money—£18,000 a month—have been expended. A report from P. K. Horner on the subject is expected soon. Until this is available, little can be said, for there are divergent views in circulation.

A SHORT time ago I mentioned that the Rhodesia Exploration Company had brought an action against the Globe & Phoenix Gold Mining Company for permission to inspect the underground workings. The Globe & Phoenix at first resisted the action, but has now withdrawn its appeal and arrangements will be made for examination and survey.

Now that the price of tin has fallen to less than £250 per ton, the question of control is again to the front. And yet it does not seem to meet with general favor. The matter largely turns upon the level of working costs. It is said that if a further fall in price takes place, many of the Malayan native-worked areas will become unprofitable. Some of the large-scale producers, with extensive properties and proved ore reserves, can still earn handsome profits with the metal at £250 a ton, and the directors do not see any advantage in carrying high-cost producers on their backs.

Ore reserves of the East Rand Proprietary Mines, as of Dec. 31, are estimated at 3,130,000 tons of an average value of 6.4 dwt. This total includes a portion of the Cinderella ore reserve taken over on the amalgamation; the balance has not yet been valued. Twelve months ago the aggregate was 2,415,000 tons.

Book Review

GOODMAN MINING HANDBOOK. Goodman Manufacturing Company, Chicago. Fifth edition, 1927.

DESPITE the fact that the last 90 pages of this 432-page volume are avowedly a catalog of the manufacturer-publisher's products, the remainder is of such a nature as to place it within the category of technical handbooks. The practical data, information, and advice contained make it well worth a place in every engineer's library. In the section on power plants and equipment, for instance, the points to be considered in determining whether to purchase power or to generate it are discussed; likewise the matter of selecting the proper location for a plant. The descriptive matter in general is clearly and readably written, and is actually interesting as well as instructive. Some ten pages are devoted to the subject of motor troubles—how to detect them and remedy them, the faults, methods of detection and the corrective procedures being tabulated for easy reference. Especially valuable are the sections on mine-haulage calculations, layout of mine tracks and switches, and rail bonding. Thirteen pages are given to the solution of typical problems in mine hoist calculations for those who wish to do this work for themselves. Among the remaining sections of interest to metal mining men are those on wire rope, pumps and pumping, mechanical power transmission, soldering and brazing, and concrete and concrete mixtures.

GEOPHYSICS—A résumé of geophysical prospecting methods is contained in the *Proceedings* of the Australasian Institute of Mining and Metallurgy dated March 31, 1927, which has just come to hand. The authors are H. W. Gepp, J. F. Hughes, and H. S. Elford. Generous excerpts from other publications are included, and duly credited, in this article.

CHINA'S MINERALS—The same bulletin also contains a 73-page article on Chinese non-ferrous metals, by Robert Slessor. This paper is very comprehensive, covering as it does the ore deposits and mining and smelting methods, as well as customs, native labor, and other related topics.

ZINC—E. H. Fraser is the author of two articles on zinc appearing in the *Proceedings* (dated June 30, 1927) of the Australasian Institute. These are: "Drying and Roasting of Concentrates at the Zeehan Works of Electrolytic Zinc Company of Australasia, Limited," and "Concentration of Ore from the Read-Roseberry Mines of Electrolytic Zinc Company of Australasia, Limited."

STOPE FILLING—E. Barkley is the author of a paper on "Stope Filling at Mt. Lyell Mine," which appears in the bulletin mentioned in the preceding paragraph.

ZINC—H. Edwin Coley has contributed a paper entitled "A Process for the Extraction of Zinc and Other Metals From Ores," which appears in the January *Bulletin* of the Institution of Mining and Metallurgy.

MINE VENTILATION—J. P. Rees is the author of a paper on the "Measurement of Low Air Velocities in Mines," which also appears in the January *Bulletin*.

WATER TREATMENT—Another article in this bulletin is that on "Boiler Water Treatment," contributed by Victor T. Edquist. The practice at the Sons of Gwalia mine, in Western Australia, is discussed.

FLORIDA, RESOURCES — The Florida State Geological Survey announces that its 18th Annual Report is ready for distribution. It is in two parts—namely, the administrative report, including statistics for mineral production for 1925 (postage 2c.); and "Natural Resources of Northern Florida" (7c.).

MINERAL RESOURCES—Part I (Metals) and Part II (Non-Metals) of "Mineral Resources of the United States" have been issued by the Bureau of Mines. They cover the year 1924, reminding the reader that time does fly.

LIME — The first installment of an article entitled "Lime Burning Practice Based on European and American Observations" appears in *Rock Products* for Jan. 21, 1928. The author is Victor J. Azbe.

PATENTS

DUST COLLECTOR — No. 1,650,292. Nov. 22, 1927. Hugh Miscampbell, Duluth, Minn.

A dust-discharging stack having a hollow shaft suspended within a horizontal section of the stack, the shaft having radially disposed arms discharging directly against the inner surface of the corrugations of the stack.

WOOD PRESERVATION—No. 1,650,274. Nov. 22, 1927. Arthur M. Howald, Pittsburgh, assignor to the Grasselli Chemical Company, Cleveland.

A process of improving the penetrative properties of oily wood-impregnating materials which consists in dissolving triethelnolamine therein.

TIMBER HOIST—No. 1,650,316. Nov. 22, 1927. A. W. Bell, Sr., and H. L. Jennings, Uniontown, Pa.

A timber hoist (for mines) consisting of a rotatable threaded shaft arranged vertically with a timber supporting carriage adapted for vertical movement on the shaft.

FILTER PRESS—No. 1,650,138. Nov. 22, 1927. Max Korff, New York, assignor J. P. Remberg Aktiengesellschaft, Barmen-Rittershausen, Germany.

A filter press having leaves of the disk type.

CLASSIFIER—No. 1,650,239. Nov. 22, 1927. F. W. Schmidt and William M. Green, Morristown, N. J.

A hydraulic classifier and separator for sorting heterogeneous materials.

POWER SHOVELS — No. 1,650,255. Nov. 22, 1927. Alfred E. Bannister, Duluth, Minn.

A mechanical shovel having a jib pivotally mounted within the carriage and a cylinder beneath the jib and forward of the pivotal connection for raising and lowering it.

ZINC METALLURGY — No. 1,652,184. Dec. 13, 1927. John Skogmark, assignor of one-half to March F. Chase.

The process of extracting zinc from zinc-bearing materials in a shaft furnace, using carbonaceous fuel and an air blast, and removing the zinc vapor from a zone in the shaft.

REFRACTORY — No. 1,650,577. Nov. 22, 1927. Paul G. Willetts, Berlin, Conn., assignor to Hartford-Empire Company, Hartford, Conn.

A refractory body having a facing of substantially pure zirconium oxide that is partially interpenetrated with it.

PRECIPITATION—No. 1,650,105. Nov. 22, 1927. Evald Anderson, assignor to International Precipitation Company, Los Angeles.

An apparatus for electrical separation of suspended particles from gases.

ROCK DRILL. No. 1,656,540. Jan. 17, 1928. W. A. Smith, assignor to Ingersoll-Rand Company.

A blowing device for a rock drill. Patent No. 1,656,541, assigned by the same individual to Ingersoll-Rand Company, covers a valve for rock drills.

TRAMWAY—No. 1,652,209. Dec. 13, 1927. M. P. Morrison, Worcester, Mass., assignor to the American Steel & Wire Company.

An aerial tramway bucket having certain features.

MERCURY—No. 1,650,360. Nov. 22, 1927. R. W. Hyde, Summit, N. J., assignor to Dwight & Lloyd Metallurgical Company, New York.

A process of distilling mercury from native ores.

DRILL BIT—No. 1,650,492. Nov. 22, 1927. A. A. Coaton, Springs, South Africa.

A percussive rock drill tool with a cutting end of original design.

ROCK DRILL. No. 1,656,567. Jan. 17, 1928. J. V. Rice, Jr., assignor to F. E. Tasker, New York.

A fluid pressure starter for gasoline drills.

GRINDING MILL. No. 1,656,756. Jan. 17, 1928. Clarence E. Payne, Empire, Colo.

HOIST—No. 1,657,165. Jan. 24, 1928. E. B. Lear, Phillipsburg, N. J., assignor to Ingersoll-Rand Company.

Certain features in a double-drum hoist.

CAR DUMPER. No. 1,655,801. Jan. 10, 1928. Joseph B. Strauss, Chicago, Ill.

Personal Notes

T. S. DAVEY, general manager of the Kay Copper Corporation, is in New York City.

ARTHUR TERRY, Canadian representative for the Dorr Company, sailed for South Africa recently.

FRANCIS L. BOSQUI, metallurgist of the Rand Mines, is now traveling through the Western States.

H. M. KINGSBURY, of the American Metal Company, has returned from South America and is now in New York.

ALBERT B. SILVER, metallurgical engineer of Tonopah, Nev., has returned to Tonopah after a business trip to New York City.

CASIMIR KALITZKY, geologist for the Soviet government in Russia, was a recent visitor at the University of Arizona, Tucson, Ariz.

EDWIN HIGGINS, mining engineer, is now secretary and managing director of the Chamber of Mines and Oil, Los Angeles. D. S. KILGOUR is auditor and assistant secretary.

HENRY WYMAN, general manager for the Minerva Mining Company, operating in Asientos, Aguascalientes, Mexico, has been in New York for a week on business connected with his company.

J. W. CALLINAN, president of the Callinan Flin Flon Mines, has returned to Toronto. He reports a great rush of prospectors and mining men to the northern Manitoba district.

P. H. ZYDERVELD, for some time metallurgist with the Patiño Mines & Enterprises, has accepted the position of assistant mill superintendent with the Huanuni company, Oruro, Bolivia.

H. R. EDWARDS, engineer in charge of dredging operations for the Natomas company in California, has resigned to accept a position with an English mining company as manager of dredging operations.

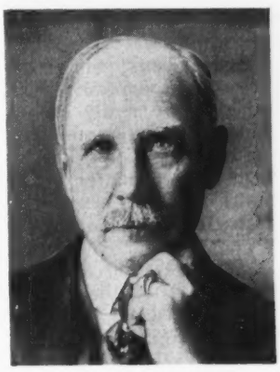
J. A. STEVENS has been appointed secretary at London of De Beers Consolidated. A. MCPHERSON was appointed assistant secretary at the same time. They succeed Messrs. Bruce and Bovanizer, who are retiring after 40 years of service with the company.

W. H. WOODS, mining engineer, who has been engaged for some time in the Rouyn mining field of Quebec, and A. COCKSHUTT, mining engineer, of Haileybury, Ont., representing Eastern financial interests, have gone to northern Manitoba to investigate mining properties.

W. W. TAYLOR, formerly engaged in construction work for the Braden company in Chile, and on the Douglas smelter and the new plant of the U. S. Steel Corporation at Youngstown, Ohio, has gone to Buenos Aires to superintend subway construction for United Engineers & Constuctors, Inc., successors to Dwight P. Robinson & Company.

David W. Brunton

The news of the death of David Brunton will have caused a pang of regret to his many friends at home and abroad. He died at Rochester, Minn., on Dec. 20, after an operation, which he had been anticipating since his illness last February. Brunton was one of a group of Canadian-born Americans that have played a notable part in the mining and metallurgical industries of the United States; he was born at Ayr, Ontario, in 1849. His parents came from Scotland, as his way of speaking not infrequently suggested.



DAVID W. BRUNTON

His father was an engineer, and he himself as a boy was trained for the same profession, in part at the University of Michigan. While a student there, at the age of 26, he was offered employment as a mining engineer in Colorado, where he met James Douglas, on whose invitation he became metallurgist for the Hunt, Douglas & Stewart Company at Georgetown. In 1879 he went to Leadville and joined with F. M. Taylor in building a custom mill, in which the Washoe process was operated profitably. He engaged in general practice, and later became manager of the Colonel Sellers mine, for which he designed a mill in which the galena and blende of a complex ore were separated successfully. In 1886 he went to Aspen as expert in a series of apex suits, and in this litigation he manifested a mental alertness that made him much in demand in such cases. He became manager of a group of important mines at Aspen, on Smuggler Mountain, which he tapped and drained by means of the Cowenhaven adit, an important engineering work. He was influential in the adoption of electrical machinery at a time when it was in its infancy, for he was always forward-looking and receptive to new ideas. In 1890 Mr. Brunton went to Butte to participate in mining litigation on behalf of the Anaconda and other companies. To him the preparation for such litigation was a means of gathering geologic data, particularly such as aided the search for orebodies. For this purpose he devised a system of mine maps upon which the relation between the workings themselves and the structural geology, more particularly the faults, was clearly indicated. During these years he was associated continuously with Frank Taylor in the business of sampling ores in custom mills, of which several were built at central points in Colorado, Utah, and Montana. This was a profitable business, mainly because it was conducted not only with approved integrity but with scientific acumen. In 1904 he patented his pocket transit, which did much to make him pleasantly known all over the world, and during the Great War he adapted the instrument to military uses, so that it now forms part of the standard equipment in the United States Army. He was engaged by the Cripple Creek Mine Owners Association to plan and construct a drainage adit, and while doing this work he used the new type of water-fed hammer drill that is known now as the Leyner, which became so popular on the Rand shortly thereafter. His reputation became international, and he was retained in an advisory capacity by the Rio Tinto company in 1903. This entailed several interesting visits to the company's copper mines at Huelva, in Spain. During the war he was a member of the Naval Consulting Board, which had to consider inventions submitted to the government for use in warfare. At the close of his service at Washington he returned to his home at Denver, where he continued to take a lively interest in engineering affairs, his honorable prominence in the profession being recognized in 1926 by the award to him of the Saunders medal by the American Institute of Mining and Metallurgical Engineers, an award that, it is fair to say, did more to give distinction to the medal than to its recipient, for David Brunton at the time was the dean of the mining profession in America; indeed, difficult as it may be, and injudicious, perhaps as well, to appraise the relative merits and performances of individuals, it seems to me that Brunton, in character and achievement, was second to none of the mining engineers of his day and generation. He abstained from the tricky phases of mining, such as share gambling and company promotion; he stuck to straight engineering work, and thereby preserved the scientific poise needed for such undertakings. He was progressive and independent in ideas; he preferred a few friends to cheap popularity; he was true to his convictions and loyal to his comrades; he was kindly and appreciative; he was sturdy in character and versatile in ability; he was an accomplished engineer and a good citizen. To realize that he is gone is a sorrow now; to remember him will be a gladness always.

T. A. RICKARD.

News has been received of the death of Mrs. Katherine K. Brunton, widow of David W. Brunton, in Denver on Feb. 1.

Market and Financial News

American Dollar Becomes Gold Standard of World Values

REGINALD McKENNA, formerly British Chancellor of the Exchequer and now head of the gigantic Midland Bank, has caused quite a stir in financial circles by declaring that the purchasing value of the American dollar is the "real determinant of movement in the general world level of prices." This in turn can be to a considerable extent controlled by the arbitrary action of the U. S. Federal Reserve banks. Excerpts from Mr. McKenna's statement follow:

Nearly three years have elapsed since the pound sterling was re-established on the gold basis, and most of the important currencies are now stabilized in relation to gold. This general reversion to gold gives the appearance of a return to pre-war conditions in matters of credit and currency, but if we look further into the question we shall find that there has been a remarkable change. The development of central bank policy in the United States has shown that, while gold may be retained as a medium for making international payments, it can be deprived of its function as the ultimate standard of value. How this came about, the stages through which American policy has passed, and the meaning of the conclusion deserve our close attention.

Let me begin by reminding you of the conditions before the war. At that time the central banks adopted a purely passive attitude with regard to the control of credit, allowing the movement of gold into or out of a country to regulate the internal supply of money. If gold flowed in freely, credit and currency expanded; if more credit was created than was required to support the current growth of business, prices rose. If gold flowed out, credit and currency contracted; the growth of business was checked and prices showed a tendency to fall. It followed from this that the current course of world prices was determined by the supply of monetary gold. This does not mean that other causes, such as improved methods of production and communication, do not affect the price level, but these come into play only over extended periods.

This passivity of the central banks probably arose from the peculiar structure of the British central banking system. London was then the unchallenged financial center and free gold market of the world. In addition, Britain, as the world's principal creditor, was the main source of supply of new capital, and international trade was for the greater part financed by sterling bills. These various factors taken together constituted London the point through which a surplus or scarcity of gold made its influence felt, and the British price level was the medium through which gold operated on the price levels of all other countries.

Under the British central banking system only a small part of the country's total gold holding was available to meet a demand. So small indeed was the primary reserve in relation to the demands which might possibly be made upon it, that the principal aim of our central bank policy was to protect it from withdrawals of gold, even when these were really of quite moderate dimensions in relation to the total stock of the country. The movement of gold became a matter of the utmost importance, and the means of counteracting its influence on the supply of money and the course of prices hardly existed. In these circumstances there was little scope for the formulation or exercise of conscious policy, and the principles of central bank credit control remained undeveloped, if not unknown.

The first authoritative suggestion that gold movements need not have predominant importance in the control of credit and currency appeared in the recommendations of the international economic conference held at Genoa in 1922. The Financial Commission appointed at that conference, perhaps the most important of its kind that has been held, were deeply impressed by the danger of a gold shortage. As advised by most of the leading authorities, the commission took the view that a scarcity was to be looked for in the absence of any unforeseen developments in production.

They were alarmed at the prospect of the supply of gold to the principal trading countries of the world becoming inadequate to provide for such an expansion of credit and currency as would be needed to meet the requirements of growing trade. Accordingly the commission's recommendations were aimed at economizing the use of gold, and one of their main suggestions was that instead of reverting to the pre-war system, under which each country held its own gold stock, gold exchange standards should be adopted by most countries, leaving only a few to hold the ultimate metallic reserves for the entire world.

The eager desire to accumulate metallic reserves is no doubt prompted by the recollection of pre-war practice and ignores our more recent experience that, even in a gold standard country, gold need no longer be the controlling factor in the supply of money. This brings me to the example of the United States, and I shall endeavor to outline the stages along which that country has moved in its progress from the pre-war to the post-war conceptions of monetary policy. If, however, the successive proceedings of the American Central Reserve Banks are to be fully understood, we must continually bear in mind a general proposition which lies at the root of monetary theory and to which I have referred on several previous occasions.

Stated in the briefest terms, the proposition is that every central bank purchase and every loan by a central bank increases the cash resources of the other banks and provides the basis for an expansion in the volume of credit, or, in other words, of money; while every sale by a central bank or repayment of a central bank loan reduces bank cash and restricts the supply of money. This proposition holds true whatever the central bank may purchase or sell, whether it buys or disposes of gold, bills, securities or any other asset. From this it follows that central banks possess the power to regulate the supply of money irrespective of gold movements. According to their view of trade requirements they may, if they choose, wholly or partially offset a purchase of gold by a sale of other assets or a sale of gold by a purchase of assets.

If the supplies of money increase beyond the requirements of business, prices tend to rise; if, on the other hand, the supplies of money are inadequate, prices fall. The relation between money supplies and business requirements, viewed in its effect upon the price level, should then be the first care of the central banking authority, and we find on an examination of American statistics for recent years that movements in the price levels upward or downward have never been allowed to proceed far. We must therefore conclude that the monetary authorities have met with a high degree of success in the formulation and execution of their policy. This they have done under conditions of great difficulty, brought about by gold movements of unprecedented magnitude.

It is necessary now to observe the bearing of American monetary policy on the operation of the gold standard. Today, as before the war, the price of gold in America is fixed, and we are apt to assume that the value of gold continues to govern the value of the dollar. But such an assumption is no longer correct. While an ounce of gold can always be exchanged for a definite number of dollars, the value of the ounce will depend upon what these dollars will buy, and this, in turn, will obviously depend upon the American price level. If the price level in America fluctuated according to the movements of gold, the purchasing power or value of the dollar would still depend, as it did formerly, upon the value of gold. But we know that this is not so. As I have just shown, the American price level is not affected by

gold movements, but is controlled by the policy of the Reserve Banks in expanding or contracting credit. It follows, therefore, that it is not the value of gold in America which determines the value of the dollar, but the value of the dollar which determines the value of gold.

The mechanism by which the dollar governs the external value of gold is obvious. If the price level outside America should rise in consequence of an increase in the supply of gold, America would absorb the surplus gold; if, on the other hand, the external price level should fall in consequence of a shortage of gold, America would supply the deficiency. The movement of gold would continue until the price levels inside and outside America were brought once more into equilibrium. Although gold is still the nominal basis of most currencies, the real determinant of movements in the general world level of prices is thus the purchasing power of the dollar. The conclusion, therefore, is forced upon us that in a very real sense the world is on a dollar standard.

Such is the position as I see it today, and I am naturally led to ask how long it is likely to continue. America is able to control the world price level because of two conditions. In the first place, her gold stocks are so great that she can afford to lose large quantities without running any risk of the gold reserve falling below the legal minimum; in the second place, her central banking system is so constituted that, given her great wealth, she can absorb large quantities of gold and at the same time deprive it of its credit creating powers. In a word, America is rich enough either to lose gold or to gain it. She holds now one-half the total monetary gold of the world.

Moreover, her creditor position constitutes a permanent magnet for gold. Her debtors must pay, and, if they can find no other way, they must pay in gold.

The only condition, as far as I can judge, under which America might be drained of her gold surplus is that she should continuously make foreign loans beyond her true capacity to lend. That she will lend excessively at times is quite probable—there are indications, indeed, that she has done so recently; it is by no means an uncommon practice with ourselves, but that she should overlend so heavily as to make a serious inroad into her surplus gold seems to me very unlikely. I conclude that as long as conditions remain at all similar to those we know today America will be able to pursue her credit policy without regard to gold movements, and to maintain control over the world level of prices.

Tri-State Company Leases New Tract

The Tri-State Mining Company will begin drilling for lead and zinc soon on a twenty-acre tract situated near Stotts City, Mo. The company recently closed a lease on the tract.

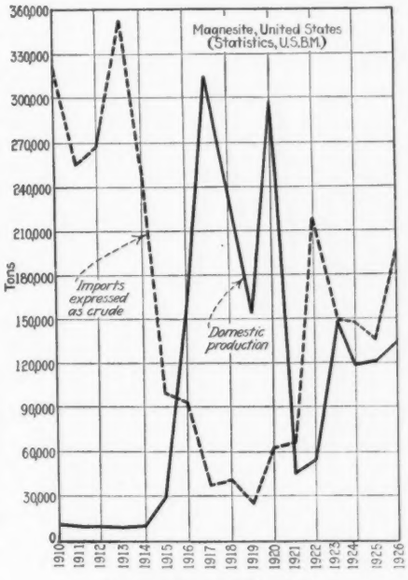
Activities in Manitoba Mines

AN IMPORTANT northern Manitoba project, the Sherritt-Gordon company, recently issued 666,666 shares of stock at $4 a share, to be sold in the proportion of one share of new stock for each six shares held. Large blocks of Sherritt-Gordon are held by other companies, two of these being the Bedford and McDougall mines, both of Quebec, each of which owns 150,000 shares of Sherritt-Gordon. Both these companies have announced that they intend to hold their Sherritt-Gordon stock and to take up the new stock.

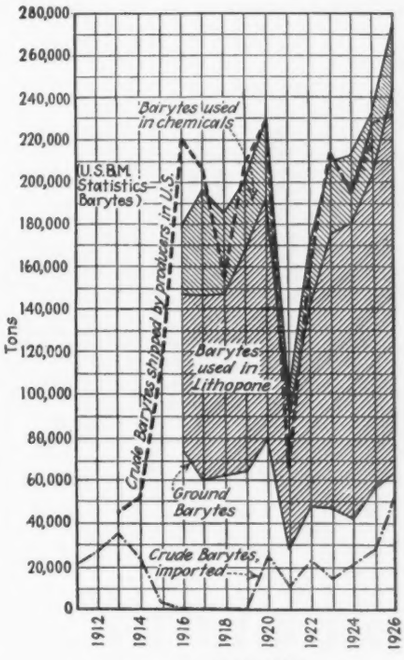
Tonopah Mining Company, of Philadelphia, announces that a consolidation of its interests in northern Manitoba has been effected. These interests include the Mandy mine, in the Schist Lake district; also certain other affiliated companies and outside properties. A new company known as Mandy Mines, Ltd., is being organized under Dominion charter, with a capital of 3,000,000 shares of no par value. Of these shares, 2,500,000 will be issued as payment for the different properties and cash for working capital. Upon completion of the financing, the new company will have $700,000 cash and 500,000 shares in the treasury. Tonopah Mining will continue to control and operate the property and will have the majority of the board of directors. Among the directors will be F. M. Connell and J. H. C. Waite, both of Toronto, who were responsible for effecting consolidation and arranging the financing. The Mandy mine was operated by Tonopah Mining during the war. As soon as the financing is completed the property will be developed and equipped.

TEXAS GULF SULPHUR COMPANY reports for the year ended Dec. 31, 1927, gross income of $22,328,199.27. Dividend payments amounted to $10,160,000 at the rate of $4 per share on 2,540,000 shares.

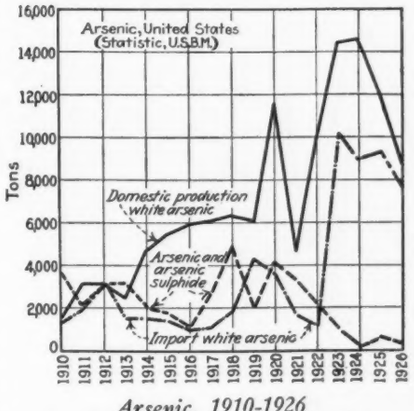
Barytes, Potash, Arsenic, and Magnesite Production, Imports, Uses



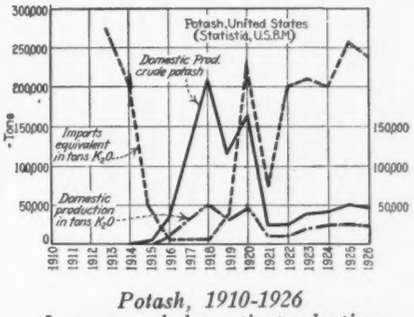
Magnesite, 1910-1926
Imports and domestic production



Barytes, 1912-1926
Imports and Uses



Arsenic, 1910-1926
Imports and domestic production


Potash, United States (Statistic, U.S.B.M.)
Domestic Prod. crude potash
Imports equivalent in tons K_2O
Domestic production in tons K_2O
Tons

Potash, 1910-1926
Imports and domestic production

The Market Report

Lead, Tin, and Zinc Markets Droop; Copper Fairly Steady

New York, Feb. 15, 1928—After ruling at 6.50c. for two and one-half months, the price of New York lead has been cut; tin continues its downward course; zinc has eased slightly; but copper prices are pretty well maintained, with "primary" producers firm at 14.125c., Connecticut, in spite of some shading on the part of custom smelters. Business has not been brisk in any of the metals, although the cut in lead stimulated some buying.

Little Change in Copper

The copper situation is much the same as it has been for a month or more. Tonnage sold is well below average, but producers continue to resist pressure to cut the price below 14.125c., delivered in the Valleys. Some sales at this figure have been made each day during the week, but the bulk of the "high-priced" transactions were for delivery at high freight-rate destinations at 14.25c. On the other hand, sales at various prices between 14.00 and 14.10c. have been made, the lowest being reached today, when one lot was sold for 14c. Foreign business has been quiet at the exporter's price of 14.50c. c.i.f.

The question that bothers producers is whether the protracted dullness is merely building up a tremendous demand that eventually will assert itself, or reflects a serious falling off in orders being put on the books of fabricators. One view is that the customers of the fabricators are holding off in the expectation that the price of metal will break and bring down the prices of fabricated products with it.

Lower Lead Prices Attract Buyers

Predictions made two or three months ago that lead prices would advance before they would decline now appear to have been uninspired, for last Friday, Feb. 10, the American Smelting & Refining Company cut its contract price from 6½c., New York, at which level it had held since Dec. 1, to 6.35c. Other producers met the cut, and in fact, in the last day or two, it might have been possible to shade this price by 5 points or so. The St. Louis market has also weakened, lead having been sold in the last two days at various prices between 6 and 6.15c., whereas a week ago the market held around 6.225c. Lead at the even figure of 6c. was obtainable only in large lots for early delivery.

Producers are frankly uneasy over the drop in London, which has been largely accountable for the decline on this side. It is feared that this time lead may break through £20 in that market, and, if it does, further declines in domestic prices are not at all unlikely. United States producers are not burdened with excess stocks, but the market cannot stand an inflow of bullion lead from foreign sources, which would have resulted had not prices been reduced.

Buying of lead has been fairly active since the prices dropped, with all classes of consumers in the market to some extent, and early delivery generally in most demand.

Tin Drops Almost 2c.

Straits tin for prompt delivery sold today at 51¼c., a drop of 1¾c. from a week ago and the lowest point reached on the present movement. Three years ago, on a similar movement, tin struck bottom at 50c., but followers of the market are not so sure that the metal may not drop into the forties this time, as Far Eastern production has expanded with the increased number of dredges put into service last year, and consumption is

Daily Prices of Metals

Feb.	Copper	Tin		Lead		Zinc
	Electrolytic, N. Y.	99 Per Cent	Straits	N. Y.	St. L.	St. L.
9	13.85@13.90	52.25	53.125	6.50	6.20	5.60@5.625
10	13.85@13.90	51.50	52.25	6.35	6.15	5.60@5.625
11	13.80@13.85	51.25	51.875	6.35	6.125@6.15	5.60@5.625
13	Holiday	.....	.....	....	.....	.....
14	13.80@13.90	51.50	52.00	6.30@6.35	6.00@6.15	5.60
15	13.775@13.875	50.75	51.25	6.30@6.35	6.00@6.15	5.575
	13.850	51.450	52.100	6.370	6.128	5.603

Average prices for calendar week ending February 11, 1928, are: Copper, 13.860; 99 per cent tin, 52.146; Straits, 52.833; N. Y. lead, 6.450; St. Louis lead, 6.192; zinc, 5.629; and silver, 56.854.

The above quotations are our appraisal of the major markets for domestic consumption based on sales reported by producers and agencies. They are reduced to the basis of cash, New York or St. Louis, as noted. All prices are in cents per pound.

Copper, lead, and zinc quotations are based on sales for both prompt and future deliveries; tin quotations are for prompt delivery only.

In the trade, copper prices usually are quoted on a delivered basis; i.e., delivered at consumer's plant. As delivery and interest charges vary with the destination, the figures shown above are net prices at refineries on the Atlantic seaboard. Delivered prices in New England average 0.225c. per pound above those quoted, and prices at so-called Middle West destinations, 0.325c. above.

Quotations for copper are for ordinary form of wire bars, ingot bars, and cakes. For ingots an extra 0.05c. per pound is charged and there are other extras for other shapes. Cathodes are sold at a discount of 0.13c. per pound.

Quotations for zinc are for ordinary Prime Western brands. Zinc in New York is now quoted at 0.35c. per pound above St. Louis, this being the freight rate between the two points.

Quotations for lead reflect prices obtained for common lead, and do not include grades on which a premium is asked.

London

Feb.	Copper			Tin		Lead		Zinc	
	Standard		Electrolytic	Spot	3M	Spot	3M	Spot	3M
	Spot	3M							
9	61 7/8	61 1/2	66 1/2	238	240 1/2	20 3/4	21 1/4	25 7/8	25 13/16
10	61 13/16	61 1/2	66 1/2	233	235 1/4	20 5/16	20 7/16	25 7/8	25 7/8
13	61 11/16	61 5/8	66 1/2	227 3/4	230	20	20 1/2	25 5/8	25 5/8
14	61 15/16	61 9/16	66 1/2	231 1/4	233 3/4	20 3/16	20 3/4	25 11/16	25 11/16
15	62 1/4	61 7/8	66 1/2	229	231 1/2	20	20 9/16	25 11/16	25 5/8

The above table gives the closing quotations on the London Metal Exchange. All prices in pounds sterling per ton of 2,240 lb.

Silver, Gold, and Sterling Exchange

Feb.	Sterling Exchange "Checks"	Silver		Gold London	Feb.	Sterling Exchange "Checks"	Silver		Gold London
		New York	London				New York	London	
9	4.86 3/4	57	26 1/4	84s11 1/2d	13	Holiday	.....	26 3/8	84s11 1/2d
10	4.86 15/16	57 1/8	26 3/8	84s11 1/2d	14	4.87	57 1/4	26 5/16	84s10 1/2d
11	4.87	57	26 1/4	.....	15	4.86 15/16	57 1/8	26 1/4	84s11d
					Avg.		57.100		

New York quotations are as reported by Handy & Harman and are in cents per troy ounce of bar silver, 999 fine. London silver quotations are in pence per troy ounce of sterling silver, 925 fine. Sterling quotations represent the demand market in the forenoon. Cables command three-eighths of a cent premium.

apparently somewhat restricted. Consumers have been buying on the breaks and traders have been selling. Forward prices are slightly less than prompt, but the difference is hardly more than $\frac{1}{8}$c.

Zinc at 5.575c.

Dullness has pervaded the zinc market and prices have softened. Metal is to be had today at as low as 5.575c., with small variations with respect to different months of delivery. The following statistics for January have just been released by the American Zinc Institute:

Stock, Jan. 1	40,751
Production	52,414
Total	93,165
Shipped	51,002
Stock, Jan. 31	42,163
Retorts operating at end of period	72,204

Silver 57$\frac{1}{8}$c.

The silver market continues quiet and steady, with very small fluctuations. India has shown little interest, and London reports China both a buyer and seller, although buying for China account has been the chief support of the local market.

Mexican Dollars (Old Mexican pesos): Feb. 9th, 43$\frac{5}{8}$c.; 10th, 43$\frac{3}{4}$c.; 11th, 43$\frac{3}{8}$c.; 13th, holiday; 14th, 43$\frac{7}{8}$c.; 15th, 43$\frac{3}{4}$c.

Foreign Exchanges Steady

Foreign exchange rates have for the most part been steady in the last week. Closing cable quotations on Tuesday, Feb. 14, were as follows: Francs, 3.93$\frac{1}{2}$c.; lire, 5.295c.; and marks, 23.845c. Canadian dollars, $\frac{3}{32}$ per cent discount.

Other Metals

Quotations cover large wholesale lots unless otherwise specified.

ALUMINUM—Per lb., 98 or 99 per cent grades, price of leading interest, 24.30c.; outside market, 23.90@24.30c.

ANTIMONY—Per lb., duty paid. New York: Chinese brands, spot business, range for the week 10$\frac{7}{8}$@11c. Forward positions through April almost the same.

Cookson's "C" grade, spot, 16$\frac{3}{8}$c. Needle antimony nominally 8c. for lump and 10c. for powdered. White oxide, Chinese, 99 per cent Sb_2O_3, 15$\frac{1}{2}$c.

BISMUTH—Per lb., New York, in ton lots, $2.20. Smaller lots, $2.30 and up.

IRIDIUM — Per oz., $375@$390 for 98@99 per cent sponge and powder. Strong market; shortage of supply.

NICKEL—Per lb. ingot, 35c.; shot, 36c.; electrolytic, 37c. (99.9 per cent grade) for single lots of spot metal.

PALLADIUM — Per oz., $49.50@$52. Small lots bring up to $56.

PLATINUM—Official price quoted by the leading interest on small miscellaneous orders for refined metal, per oz., $85. Dealers and refiners quote the trade for refined metal, per oz., cash, $82@$83. Market very dull.

QUICKSILVER — Per 76-lb. flask, $121@$122, depending on quantity. San Francisco wires $126.67.

Prices of Cadmium, Cobalt, Germanium Oxide, Lithium, Magnesium, Molybdenum, Monel Metal, Osmium, Radium, Rhodium, Ruthenium, Selenium, Tantalum, Tellurium, Thallium, Tungsten, and Zirconium are unchanged from the issue of Feb. 4.

Metallic Ores

MANGANESE ORE—Per long ton unit of Mn. c.i.f. North Atlantic ports, minimum 47 per cent Mn; 35@38c. Caucasian, washed, 53@55 per cent, 38.50@40c. Chemical grades unchanged from quotations in the Feb. 4 issue.

TUNGSTEN ORE—Per unit of WO_3, N. Y.; Wolframite, $10.25@$10.50. Western scheelite, $10.50@$10.75. Market dead; prices nominal.

Chrome, Iron, Tantalum, and Titanium ores are unchanged from quotations in the Feb. 4 issue.

Zinc Concentrate Declines to $36

Joplin, Mo., Feb. 11, 1928.

Blende		
High		$40.90
Premium blende, basis 60 per cent zinc	$37.00@	38.00
Prime Western, basis 60 per cent zinc		36.00
Slimes and fines, 60 per cent zinc	33.00@	35.00
Average settling price, all zinc		37.92
Galena		
High		$87.60
Basis 80 per cent lead		80.00
Average settling price, all lead		85.73

Shipments for the week: Blende, 11,270; lead, 1,910 tons. Value, all ores the week, $591,390.

Buyers dropped the price offering today to a basis of $36, Prime Western, and were still trying to buy at a late hour this afternoon, but sellers were few. The total purchase was 7,020 tons. More than 3,000 tons of last week's purchase is yet in the bins of the producers, on most all of which advance payment has been made. Only those producers that were forced to sell to meet current bills accepted the price offering this week.

Lead was lowered in response to the lower metal market, but the bulk of the purchase was made before the price was reduced.

Figures for the week ending Feb. 4, follow:

Blende		
High		$41.30
Premium blende, basis 60 per cent zinc	$39.00@	40.00
Prime Western, basis 60 per cent zinc		38.00
Slimes and fines, 60 per cent zinc	34.00@	37.00
Average settling price, all zinc		37.42
Galena		
High		$88.40
Basis 80 per cent lead		85.00
Average settling price, all lead		85.57

Shipments for the week: Blende, 12,189; lead, 732 tons. Value, all ores the week, $518,780.

Purchase the week, 14,340 tons.

Platteville, Wis., Feb. 11, 1928

Zinc Blende	Per Ton
Blende, basis 60 per cent zinc	$40.75
Lead Ore	
Lead, basis 80 per cent lead	$85.00

Shipments for the week: Blende, 859 tons; lead, none. Shipments for the year: Blende, 4,366; lead, 360 tons. Shipments for the week to separating plants, 1,328 tons blende.

Non-Metallic Minerals

Amblygonite, Asbestos, Barytes, Bauxite, Borax, Celestite, Chalk, China Clay, Diatomite, Emery, Feldspar, Fluorspar, Fuller's Earth, Garnet, Gilsonite, Graphite, Greensand, Gypsum, Iron Oxide, Lepidolite, Limestone, Magnesite, Mica, Monazite, Ocher, Phosphate, Potash, Pumice, Pyrites, Quartz Rock Crystal, Silica, Spodumene, Sulphur, Talc, Tripoli, and Zircon are unchanged from prices in the Feb. 4 issue.

Metallic Compounds

ARSENIOUS OXIDE (White Arsenic)—Per lb., 4c. A few good sales made.

Calcium Molybdate, Copper Sulphate, Sodium Sulphate (Salt Cake), Sodium Nitrate, and Zinc Oxide are unchanged from prices in the Feb. 4 issue.

Ferro-Alloys

FERROMANGANESE—Per long ton, domestic and foreign, f.o.b. furnace or c.i.f. port of entry, $100 quoted for first quarter, 1928. Spiegeleisen, 19@21 per cent, $31@$32 f.o.b. furnace.

FERROTUNGSTEN—Per lb. of W contained, 75@80 per cent, 92@94c. f.o.b. works. Dullness expected for several months.

Ferrocerium, Ferrochrome, Ferromolybdenum, Ferrophosphorus, Ferrosilicon, Ferrotitanium, and Ferrovanadium are unchanged from prices in the Feb. 4 issue.

Metal Products

Rolled copper, lead sheets, nickel silver, yellow metal and zinc sheets are unchanged from price in Feb. 4 issue.

Refractories

Chrome Brick, Fireclay Brick, Magnesite Brick, Silica Brick and Zirkite are unchanged from quotations in the Feb. 4 issue.

Iron, Steel, and Coke

Iron—Per gross ton, Valley furnaces, Bessemer, $17.50; basic, $17; No. 2 foundry, $17.25.

Steel—Base prices per gross ton, Pittsburgh, billets and slabs, $33; plates, structural shapes, and soft steel bars, per pound, 1.85c.@1.95c.

Coke—Per gross ton, Connellsville furnace, contract, $2.85@$3; spot, $2.60@$2.85. Connellsville foundry, contract, $3.75@$4.25; spot, $3.75@$4.25. By-product coke, Ohio and Kentucky, $7.50; Buffalo and Detroit, $9.

Mining Stocks—Week Ended February 11, 1928

Stock	Exch.	High	Low	Last		Last Div.
COPPER						
Anaconda	New York	58⅛	55⅜	57⅛	Ja.14, Fe.20 Q	0.75
Arcadian Consol.	Boston	4⅛	3⅜	4⅛		
Ariz. Com'l	Boston	5⅜	5⅛	5⅜	Ja. 19, Ja. 31	0.25
Calumet & Hecla	Boston	23⅞	22⅛	22⅞	No.30, De.15 Q	0.50
Cerro de Pasco	New York	66⅛	63	65⅜	Ja.12, Fe.8 Q	1.00
Chile Copper	New York	41⅛	40	41	Ma. 2, Ma. 30Q	0.62
Con. Coppermines	N. Y. Curb	6	5⅛	6		
Copper Range	Boston	18⅛	17	17⅜	Ap.2, My.2, A	1.00
Crystal Copper	Boston Curb	*76	*70	*72		
East Butte	Boston	2	1⅛	2	Dec. 1919	0.50
Granby Consol	New York	41⅜	40	41⅛	Ja.15 Jy. 1 Q	1.00
Greene Cananea	New York	139⅛	129⅜	134⅛	Nov., 1920	0.50
Howe Sound	New York	44⅛	42⅛	43⅜	De.31, Ja.16, Q	1.00
Inspiration Consol	New York	20⅛	19⅛	19⅛	Ma.17, Ap.4, Q	0.25
Iron Cap	Boston Curb	3⅛	2⅞	3⅛		
Isle Royale	Boston	13⅜	13	13⅜	Fe. 28, Ma. 15	0.50
Kennecott	New York	87⅛	82	86½	De. 2, Ja 3 Q	1.25
Magma Copper	New York	51⅞	49⅛	50⅛	De.30, Ja.17 Q	0.75
Mason Valley	N. Y. Curb	1⅛	1⅛	1⅛		
Miami Copper	New York	19⅛	18⅛	19⅜	Fe.1, Fe.15, Q	0.37½
Mohawk	Boston	48⅛	47⅛	48⅛	Ja. 28, Ma. 1 Q	1.00
Montana-Idaho	Spokane	*50½	*46⅛	*47		
Mother Lode Coal	New York	3	2⅛	3	De.16, De.31	0.25
Nevada Consol	New York	23⅛	20⅛	21⅛	De.16, De.31 Q	0.37½
New Cornelia	Boston	27⅛	27⅛	27⅛	Fe. 3, Fe. 20 Q	0.50
Noranda	N. Y. Curb	20	18	19⅛		
North Butte	Boston	1⅛	1	1	Oct., 1918	0.25
Ohio Copper	N. Y. Curb	*93	*85	*85	Sept. 1926	0.03
Old Dominion	Boston	10⅞	9⅛	10	Dec., 1918	1.00
Phelps Dodge	N. Y. Curb	125	123⅛	124⅛	De.17, Ja. Q	1.50
Quincy	Boston	14	13	13	March, 1920	1.00
St. Mary's Min. Ld.	Boston	29⅛	28	29	Fe.10, Ma.10	2.00
Seneca Copper	New York	2⅛	2⅛	2⅛		
Shattuck-Denn	Boston Curb	17⅛	12⅛	15⅛		
Tenn. C. & C.	New York	11	10⅛	11	Fe.29, Ma.15, Q	0.12½
United Verde Ex	N. Y. Curb	23⅛	23	23	Ja.4, Fe.1 Q	0.50
Utah Copper	New York			145	De.16, De.31 Q	1.50
Utah Metal & T	Boston	1⅛	1⅛	1⅛	Dec., 1917	0.30
Walker Mining	Salt Lake	1.55	*77	*78		
NICKEL-COPPER						
Internat. Nickel	New York	98⅛	90⅜	94	De.16, De.31 Q	0.50
Internat. Nickel pfd.	New York	112⅛	112	112⅛	Fe. 17, Ma. 1 Q	0.62½
LEAD						
Gladstone Mtn	Spokane	*9⅛	*7⅛	*8	June, 1927	0.005
National Lead	New York	134⅛	131	131	De. 16, De. 31 Q	1.25
National Lead pfd	New York	139	139	139	Ma. 2, Ma. 15Q	1.75
St. Joseph Lead	New York	42	40⅜	41	Ma.9, Ma.20, QX	0.75
ZINC						
Am. Z. L. & S.	New York	16	8⅞	15⅛	May, 1917	1.00
Am. Z. L. & S. pfd.	New York	77	60⅛	74⅛	Nov., 1920	1.50
Butte C. & Z.	New York	4⅛	4⅛	4⅛	De. 9, De. 24	0.50
Butte & Superior	New York	12⅛	9⅛	11⅛	De.16, De.31 Q	0.50
Callahan Zn-Ld	New York	2⅛	2⅛	2½	Dec., 1920	0.50
Consol. Lead&Zinc'A'	St. Louis	14½	14	14	Ma.15, Ap.1 Q	0.25
Eagle-Picher	Cincinnati	21⅞	18⅜	18⅜	No.15, De.1 Q	0.40
Eagle-Picher pfd	Cincinnati	117	115⅛	115½	Jn.30, Oc.15 Q	1.50
New Jersey Zn	N. Y. Curb	191⅛	188⅛	190½	Ja. 20, Fe. 10	2.00
United Zinc	N. Y. Curb			25		
Yellow Pine	Los Angeles			*25	Dec. 1925 Q	0.04
GOLD						
Alaska Juneau	New York	4	3⅛	3⅛		
Argonaut	Toronto	*25⅛	*21⅛	*22⅛		
Barry-Hollinger	Toronto	*85	*74	*76⅛		
Central Manitoba	Toronto	1.71	1.55	1.60		
Con. W. Dome L. new.	Toronto	*14⅛	*12⅛	*14⅛		
Cresson Consol. G	N. Y. Curb	2⅛	2	2⅛	Ma.31, Ap.10 Q	0.10
Dome Mines	New York	12½	11⅞	12⅛	Ma. 31, Ap. 20Q	0.25
Golden Cycle	Colo.Springs	†1.75	†1.73		Fe.29, Ma.10 Q	0.04
Gold Hill	Toronto	*28⅛	*24⅛	*25		
Hollinger Consol	Toronto	18.00	17.00	17.15	Ja.1, Ja.27 M	0.10
Homestake Mining	New York			.69	Fe.20, Fe.25 MX	1.50
Kirkland Lake	Toronto	2.21	1.96	2.12		
Lake Shore	Toronto	24.90	21.85	22.50	De.1, De.15 QX	0.20
McIntyre-Porcupine	New York	27⅜	27	27	Fe. 1, Ma. 1 Q	0.25
Portland	Colo.Springs	†*25	†*18		Ap.6, Ap.15, Q	0.02
Rand Mines	New York			43⅛	Au.22-29 Am.Sh.	1.52
Sylvanite	Toronto	3.75	3.25	3.25		
Teck-Hughes	Toronto	9.25	8.10	8.40	Fe.1, X	0.15
Tom Reed	Los Angeles	*36	*25	*35	Dec., 1926	0.02
Tough-Oakes	Toronto	*59⅛	*53	*54		
United Eastern	N. Y. Curb	*84	*69	*70	July, 1924	0.05
Vipond Cons	Toronto	*56⅛	*54	*55⅛	Apr.1, Apr.15	0.03
Wright-Hargreaves	Toronto	5.65	4.38	4.75	Ja. 17, Fe. 1	0.05
GOLD AND SILVER						
Carnegie Metals	Pittsburgh			26⅛		
Con. Cortes	N. Y. Curb	*19	*19	*19		
Dolores Esperanza	N. Y. Curb	*57	*50	*50	July, 1923	0.05
Premier Gold	N. Y. Curb	2⅛	2⅛	2⅛	De. 15, Ja. 4	0.08
Tonopah Belmont	N. Y. Curb	1⅛	1⅛	1⅛	Ma.15, Ap.4	0.08
Tonopah Extension	N. Y. Curb	*11	*10	*11	Apr. 1925	0.05
Tonopah Mining	N. Y. Curb	4⅛	3⅛	4⅛	Se.20, Oc.21	0.07½
West End Consol	N. Y. Curb			*5	Mar., 1923	0.05
Yukon Gold	Boston Curb	*70	*60	*70	June, 1918	0.02
SILVER						
Beaver Consol	Toronto	1.76	1.61	1.67	May, 1920	0.03
Castle-Trethewey	Toronto	*79⅛	*63	*69		
Coniagas	Toronto	4.90	4.90	4.90	May, 1924	0.12½
Keeley	Toronto	*61	*59	*61	Se.1, Se.15	0.08
Lorrain Trout Lake	Toronto			*60	July, 1925	0.05
Mining Corp. Can.	Toronto	4.50	3.73	3.85	Ja.10, Ja.25	1.50
Nipissing	N. Y. Curb	5⅛	5⅛	5⅛	De. 31, Ja.20 Q	0.07½

Stock	Exch.	High	Low	Last		Last Div.
SILVER-LEAD						
Ahumada	New York	3⅛	3	3	Ma. 25, Ap.4, QX	0.12½
Bingham Mines	Boston	54	54	54	Ja. 21, Fe. 1 Q	0.95
Bunker Hill & Sullivan	N. Y. Curb			150	Ja.31, Fe.4 NX	0.75
Cardiff M. & M.	Salt Lake	*71	*71	*71	F b 5, 1927	0.10
Chief Consol	Salt Lake	4.00	3.65	4.00	Ja.10, Fe.1 Q	0.10
Consti'n Mng. & Mill'g	Spokane	*22	*20	*20		
Erupcion	Boston Curb	*55	*45	*50	De.17, Ja.3 Q	0.07½
Eureka Lily	Salt Lake	2.27½	2.17	2.22½		
Federal M. & S.	New York	140	140	140	Jn.25, Jn.29 Spec.	$10
Federal M. & S pfd.	New York	96	94⅛	96	No. 12 De 15 Q	0.25
Hecla Mining	N. Y. Curb	18	17⅛	17⅛	No.15, De.15 Q	1.75
Highland-Surprise	Spokane	*16	*14⅛	*14⅛		
Iron King Mining	Salt Lake	*75	*66	*68		
Keystone Mining	Salt Lake	2.55	2.55	2.55	Au. 12, Au. 26	0.07½
Lucky Jim	Spokane	*34	*31½	*32		
Lucky Tiger-Com	Kansas City	†8.10	†7.95		Fe.10, Fe. 20	0.07
Mammoth Mining	Salt Lake	2.05	2.05	2.05	Jn.10, Jn.20 Q	0.05
North Lily	Salt Lake	5.20	4.80	4.92½		
Park Utah	New York	12⅛	11⅛	12	De. 15, Ja. 3 Q	0.20
Plutus Mining	Salt Lake			2.40	Oc. 25, No. 10 Q	0.10
Silver King Coal	Salt Lake	11⅛	11⅛	11⅛	De. 24, Ja.2 X	0.35
Silversmith	Spokane	*23⅛	*20	*20	Oct., 1926 Q	0.02
Strattons Mines	Spokane	*50	*47⅛	*48⅛		
Sunshine M. Co.	Spokane	1.58	1.50	1.50		
Tamarack-Custer	Spokane	1.15	1.00	1.13	Sept., 1924	0.25
Tintic Standard	Salt Lake	16	15⅜	16	De.20, Ja.3 QX	0.40
Utah-Apex	Boston	4⅛	4⅛	4⅛	Oct., 1926	0.25
IRON						
Bethlehem Steel	New York	62⅛	59	60	Se. 2, Oc. 1	1.75
Cleveland-Cliffs Iron	Cleveland	106	106	106	Ja.13, Ja.25. Q	1.00
Colorado Fuel & Iron	New York	78⅞	78	78⅛	May, 1921	0.75
Gt. North'n Iron Ore	New York	23⅛	22⅛	23	Dec. 6, Dec. 28	0.75
Inland Steel	New York	58⅛	57⅛	57⅛	Fe.15 Ma.1 QX	0.66⅔
Replogle Steel	New York			12⅛		
Republic I. & S.	New York	69⅜	64	64	Fe. 15, Ma. 1 Q	1.00
Republic I. & S. pfd.	New York	112	111	111	Ma. 15, Ap. 2 Q	1.75
Sloss-Sheffield S. & I.	New York	134	129⅛	131	De. 10, De. 20 Q	1.50
Sloss-Shef. S.&I. pfd.	New York	119	119	119	De. 20, Ja.3 Q	1.75
U. S. Steel	New York	147	143	145⅛	No. 30, De. 30 Q	1.75
U. S. Steel, pfd.	New York	140	139⅛	139⅜	Oc.30, No. 29 Q	1.75
Virginia I. C. & C.	New York	34	34	34	Jan., 1924	1.50
Virginia I.C.&C. pfd.	New York	62⅛	62⅛	62⅛	De. 16, Ja. 3	2.50
DIAMONDS, PLATINUM, ALUMINUM, VANADIUM, TIN						
De Beers Consol	New York			24	Jn. 26, Jn.30	1.45
So. Am. G. & P. New.	N. Y. Curb	2⅛	2⅛	2⅛		
Alum. Co. of Amer.	N. Y. Curb	133	124	133		
Alum. Co. of Amer. pf.	N. Y. Curb	107⅛	106⅜	106⅜	De. 15, Ja1 Q	1.50
Vanadium Corp.	New York	94⅛	80⅛	82⅛	Fe. 1, Fe. 15 Q	0.75
Patino M. & E.	New York	27⅜	25⅛	27⅜	De 31, Ja. 14	4s.
ASBESTOS						
Asbestos Corp.	Montreal	35	34	35	Jan., 1926	1.50
Asbestos Corp. pfd.	Montreal	95⅛	94⅛	95	De.31, Ja.16 Q	1.75
SULPHUR						
Freeport Texas	New York	97⅜	81	84⅛	Ja.14, Fe.1 QX	1.75
Texas Gulf	New York	75⅜	69⅛	72⅛	De. 1, De. 15 Q	1.00
MINING, SMELTING, REFINING AND GENERAL						
Amer. Metal	New York	45	43	43⅞	Fe.18, Ma.1 Q	0.75
Amer. Metal, pfd.	New York	119½	116	119½	Fe.18, Ma.1 Q	1.75
Amer. Sm. & Ref.	New York	183	172⅛	181⅛	De.31, Fe. 1 Q	2.00
Amer. Sm. & Ref. pfd.	New York	134⅛	132⅜	134⅛	De.31, Ma.1 Q	1.75
Consol. M. & S.	Montreal	282	275	278⅛	De. 31, Ja. 16 X	6.25
Newmont Mining	N. Y. Curb	173⅛	158	170⅛	Ja.3, Ja. 17	1.00
U. S. Sm. R. & M.	New York	42⅛	41⅛	42⅛	Ja. 6, Ja. 14 Q	0.87½
U.S. Sm. R.&M. pfd.	New York	53⅛	52⅛	53⅛	Ja. 6, J3 14 Q	0.87½

* Cents per share. † Bid or asked. Q, Quarterly. SA, Semi-annually. M, Monthly. F, four weeks. I, Initial. X, Includes extra. The first date given is that of the closing of the books; the second that of the payment of the dividend.

Boston quotations courtesy Boston Stock Exchange; Toronto quotations those of the Standard Stock Exchange of Toronto, by courtesy of Arthur E. Moysey & Co.; Spokane, Pohlman Investment Co.; Salt Lake, J. A. Hogle & Co.; Colorado Springs, Colo., Henry Sachs.

LONDON QUOTATIONS—WEEK ENDED JANUARY 31, 1928

Name	High	Low	Last	Date	Last Div. Amount
Aramayo Mines (25 frs.)	72/6	70/—	71/3	Feb., 1928	5 p.c. (†)
British Platinum (£1)	—/3	—/1½	—/3	Feb., 1925	2½ p.c.
Burma Corpn. (10 rupees)	14/1½	13/6	13/7½	Jan., 1928	6 annas*
Bwana M'Kubwa (5s)	4/9	4/1½	4/1½		
Camp Bird (2s)	5/—	3/6	3/9		
El Oro (£1)	3/9	3/3	3/9	Nov., 1924	2½ p.c.*
Esperanza (10s)	—/1½	—/1½	—/1½		
Frontino & Bolivia (£1)	14/3	13/9	13/9	Jan., 1928	5 p.c
Mexican Corpn. (£1)	8/9	8/—	8/6		
Mexico Mines of El Oro (£1)	25/7½	18/1½	25/—	Dec., 1926	3½ p.c.*
N'Changa Copper Mining	11/—	10/—	10/6		
Oroville Dredging (£1)	4/1½	3/10½	4/—	Dec., 1923	3½ p.c.
Ouro Preto (£1)	2/6	2/3	2/3	May, 1925	2½ p.c.
Rhodesian Congo Border (£1)	29/9	26/3	26/3		
St. John del Rey (£1)	10/1½	9/10½	10/—	May, 1927	3½ p.c.
San Francisco Mines (10s)	28/—	25/9	27/—	Jan., 1928	25s. *
Santa Gertrudis (£1)	15/9	15/—	15/6	Jan., 1928	7½ p.c
Selukwe (2s. 6d.)	7/9	7/—	7/—	April, 1917	6¼ p.c
S. Amer. Copper (2s.)	—/7½	—/1½	—/6	Nov., 1917	75 p.c
Tanganyika (£1)	70/9	66/6	67/6	Aug., 1927	7½ p.c
Union Miniere du Haut-Katanga (Brussels)	12.470	11.825	12.025	July, 1927	182.60(‡

* Free of British income tax. † Swiss francs and plus 15 p. c. bonus. ‡ Belgian frs. and free of taxation.